CHAPTER XX

Atomic Mission

At a quarter of eleven on the morning of 6 August 1945, the White House solemnly announced: "Sixteen hours ago an American airplane dropped one bomb on Hiroshima, an important Japanese Army base." More powerful than 20,000 tons of TNT, the bomb was an atomic bomb capable of wiping out whole cities.[1] The statement produced a general sensation. A wave of exultation swept the United States: the war was practically over; the boys would soon be home. In London, where the story eclipsed all other news, a reporter noted: "The world has changed overnight."[2] Aboard the cruiser *Augusta*, on his way back from the Potsdam Conference, President Truman told a throng of cheering sailors: "This is the greatest thing in history."[3] Altering the course of civilization and opening a new era in the life of mankind, the release of atomic energy was a titanic task. Its achievement was a triumph for scientists, industrialists, and engineers.

As Hiroshima lay silent beneath a pall of smoke and dust and the world marveled at the scientific feat, the public learned about the Manhattan Engineer District: its hidden cities, secret plants, and secluded laboratories; its extraordinary size and scope; and its $2-billion expenditure. Early radio broadcasts told where the powerful new explosives originated—at the Clinton Engineer Works in Tennessee and the Hanford Engineer Works in the State of Washington.[4] Newspaper tributes to the genius of the bomb's developer, Dr. J. Robert Oppenheimer, appeared side by side with tributes to the driving force of the "atom general," Maj. Gen. Leslie R. Groves of the Corps of Engineers. References to other prominent Engineer officers—Reybold, Styer, Robins, and Farrell—found their way into dispatches; and Nobel laureates in physics shared the limelight with hitherto obscure Engineer colonels.[5] The castle emblem of the Corps was coupled inseparably to the armillary symbol of the atom. Yet many people at the time failed to understand fully why the castle was so prominently displayed. In the two decades that followed, many scholars also failed.

The bomb was the product of a remarkable set of circumstances. First, and basic, was the industrial power of the nation: the huge concentrations of capital goods and the great fund of

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[1] New York *Times*, August 7, 1945, p. 4. © 1945 by The New York Times Company. Reprinted by permission.

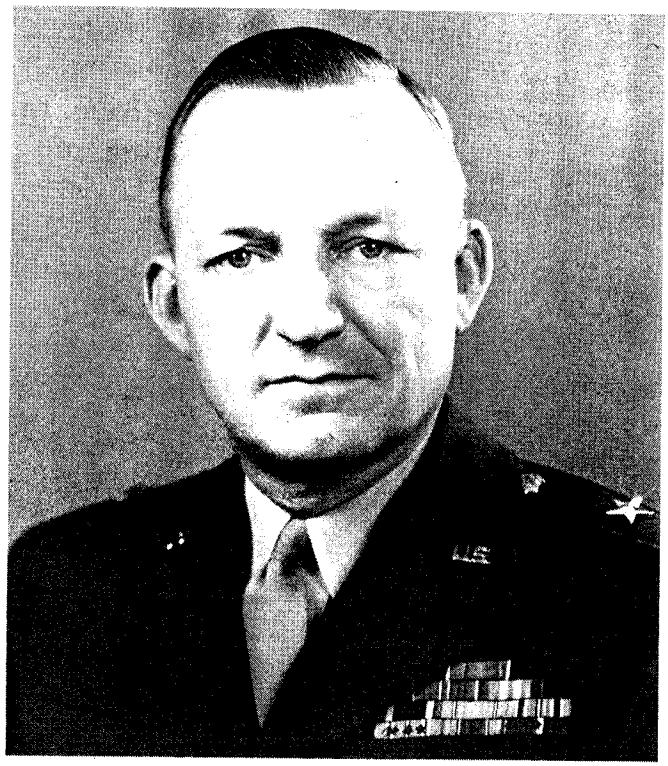
[2] *Ibid.*, p. 3.

[3] Truman, *Memoirs*, I, p. 421.

[4] Statements by Truman and Stimson, August 6, 1945. Reprinted in New York *Times*, August 7, 1945, p. 7.

[5] (1) Baltimore *Evening Sun*, August 6, 1945, pp. 1 and 3; and August 7, 1945, p. 3. (2) New York *Times*, August 7, 1945, pp. 1–3 and 6; and August 8, 1945, pp. 2–3 and 6. (3) Albuquerque *Journal*, August 7, 1945, pp. 1–2.

technical and managerial skills capable of sustaining tremendous emergency burdens. A circumstance just as vital to the realization of the weapon was the presence in the United States of a group of brilliant scientists, a number of them refugees from Europe, working feverishly against time to beat the Germans in harnessing atomic energy. But fully as essential as any other factor was the existence of a Corps of Engineers, trained and tested in large-scale construction undertakings. It was this established, knowledgeable Engineer organization, ready and at hand as an integral part of the Army, which provided indispensable leadership and support. The devastation of Hiroshima, followed three days later by the dropping of a second atomic bomb on Nagasaki, proclaimed the success of a three-year project unique in engineering annals.



BRIG. GEN. JAMES C. MARSHALL. (*Photograph taken in 1946.*)

MED: Origins and Early Efforts

A summons from the Chief to Col. James C. Marshall, on 17 June 1942, set the project going. District engineer at Syracuse, New York, Marshall was an esteemed member of the Corps. A 1918 West Point graduate, he had had a well-rounded career: duty with troops in France and Panama; service with the New York, Puerto Rico, and Binghamton Districts; study at the Engineer School and the Command and General Staff College; four years as an instructor at the Military Academy; three years with the Engineer Board at Fort Belvoir; two years as head of the New York State Barge Canal Improvement; and a tour in the Civil Works Division, OCE. Over the years he had built a reputation as a good executive, sound engineer, and gifted organizer. A polished and gracious man known to subordinates as "Gentleman Jim," an officer who coupled firmness with tact, he was a leader rather than a driver. His record at Syracuse spoke well for his methods. Responsible for a $250-million civil-military program, including a dozen major war construction projects, he could report virtually all jobs on or ahead of schedule in June 1942. Reybold's message to him bore the stamp of urgency. Checking with key assistants and making several long-distance telephone calls, he got important matters squared away. By midnight he was enroute to Washington.[6]

Twenty-four hours later, in a room at the Willard Hotel, Marshall sat, taut

[6] (1) Col Marshall's Diary, 17 Jun 42. EHD Files. (2) Ltr, Marshall to authors, 15 Jan 68. (3) Interv with Francis R. Deland, 5 Jan 68.

and weary, puzzling over the contents of a folder labeled "S–1." He had had a strenuous day: an all-night drive to New York City; an early morning conference with Colonel Dunn, the Division Engineer; an American Airlines flight to Washington; a serious talk with General Styer at the Munitions Building; and, finally, a grave session with Robins and Groves at the Chief's office. The S–1 folder belonged to Styer, who had handed it over with the explanation that Marshall had a new job: to form an Engineer district and construct plants for atomic fission bombs. Abstruse and baffling, Styer's papers mentioned several of the country's leading scientists; revealed the enormous destructive potential of a rare uranium isotope, U–235, and of a recently discovered transuranic element, plutonium; outlined four possible methods of achieving quantity production of one or the other of these fissionable materials; and put the cost of the entire program at roughly $90,000,000. "I spent the night without sleep trying to figure out what this was all about," Marshall afterward related. "I had never heard of atomic fission, but I did know that you could not build much of a plant, much less four of them, for $90,000,000."[7]

The next day Marshall gained a clearer understanding of his mission. From talks with General Styer and Dr. Vannevar Bush, who headed the Office of Scientific Research and Development (OSRD), and from documents they showed him, he learned the outline of the story: the German discovery late in 1938 that the uranium atom could be split and the impact of this news on the world of physics; the eager activity at American universities—the spurt of theoretical speculation about chain reactions, atomic power, and atomic bombs and the unaided struggle for experimental proof; Albert Einstein's letter to Roosevelt, which brought Uncle Sam into the enterprise in the fall of 1939; and the nuclear research or S–1 program carried forward under government auspices since that time. He learned, moreover, where the program stood. By the spring of 1942, the fact was plain: atomic bombs might be possible. S–1 scientists claimed to know in principle how to make the bomb stuff; in fact it seemed that they might be able to turn the trick several ways, separating U–235 from the far more abundant isotope U–238 by electromagnetic, gaseous diffusion, or centrifugal methods, and producing plutonium by bombarding natural uranium with neutrons. So far, however, none of these processes had advanced beyond preliminary laboratory stages; none had proved superior to the rest; and none had yielded as much as a microgram, though kilograms were needed to make bombs.[8] Marshall's task was unprecedented: from laboratory instruments to huge industrial

[7] (1) Ltr, Marshall to authors, 15 Jan 68. (2) Marshall Diary, 18 Jun 42. (3) Interv with Gen James C. Marshall, 19 Apr 68.

[8] (1) Marshall Diary, 19 Jun 42. (2) Ltr, Bush to Roosevelt, 17 Jun 42, and Incl thereto. MED-HB File, Folder 6. (3) For a discussion of developments prior to mid-June 1942, see Richard G. Hewlett and Oscar E. Anderson, Jr., *A History of the U.S. Atomic Energy Commission*, vol. 1, *The New World, 1939–1946* (University Park, Pa.: Pennsylvania State U. Press, 1962), pp. 9–71, cited hereinafter as Hewlett and Anderson, *The New World*; and Henry D. Smyth, *A General Account of the Development of Methods of Using Atomic Energy for Military Purposes under the Auspices of the United States Government, 1940–1945* (Washington, 1945), pp. 2–58. Cited hereinafter as Smyth, *Atomic Energy for Military Purposes*.

plants, from invisible, barely weighable "bits of nothing" to bulk lots of material a billion times as large—no engineer in history had attempted such a scale-up. Back in 1918, when Marshall was a shavetail, the Corps had flaunted the breezy motto: "It can't be done: but here it is!—U.S. Engineers." This time, obviously, the "impossible" would take longer. But it must not take too long. What Americans could do, Germans could conceivably do also.

Sensing the urgency of the job, Marshall made every day count. During his first week as Engineer of the still nameless district, he conferred with more than a dozen people, traveled more than a thousand miles, blocked out a course of action, and started organizing. After going over Dr. Bush's somewhat nebulous construction plans for a plutonium pilot plant and experiment station near Chicago, a heavy water production unit at Trail, British Columbia, and a giant industrial complex in the Tennessee Valley, he began exploring the priorities and power angles and laying the groundwork for bringing in Stone & Webster as overall AEM. On learning that OSRD was hard up for money, he arranged to tap the Corps construction funds. At the Chief's suggestion, he opened temporary headquarters in the New War Building and commenced lining up personnel. Customarily, new districts drew their cadres from older elements of the Engineer Department; and, occasionally, a single well-established district served as sponsor for one just coming into being. Familiar with the able and experienced staff at Syracuse and knowing that the workload there soon would taper off, Marshall looked to his old bailiwick for

COLONEL NICHOLS

recruits. On the 19th he chose as his deputy the area engineer at the Pennsylvania Ordnance Works, Lt. Col. Kenneth D. Nichols, a 34-year-old West Pointer whose background included several tours at the Waterways Experiment Station, canal survey work in Nicaragua, and four years as an instructor at the Military Academy. Described by associates as a scholarly type, Nichols had studied at the Technische Hochschule in Berlin and had earned two advanced degrees, an M.C.E. from Cornell and a Ph.D. from the State University of Iowa. On a weekend trip to Syracuse, Marshall also signed up Virginia J. Olsson, his attractive and efficient secretary, Charles Vanden Bulck, his resourceful administrative assistant, and Capt. Robert C. Blair, a capable civil engineer and one of the ninety-odd Syracuse Reservists on active duty with the Corps. Looking to the

future, Marshall made plans to "rob" the district systematically later on.[9]

Manhattan, he decided, would make an ideal headquarters. At first General Reybold was utterly opposed. "We will have it right here in Foggy Bottom," he said. Determined not to place himself "under the gun" in OCE, Marshall stood his ground. The New War Building was already overcrowded, while at 270 Broadway Colonel Dunn had lots of room available. Stone & Webster's main offices were in New York and Boston. You could get to Chicago or Tennessee just as easily from New York as from Washington. Besides, if you were looking for a place to hide, what better place was there than a big city. "We had quite an argument," Marshall related; but at length, Reybold gave in.[10] The issue was settled for the time being, although not for good.

At the Carnegie Institution in Washington on 25 June, Marshall and Nichols had their first get-together with Dr. Bush's scientific colleagues, the S–1 Executive Committee, OSRD. It was an eye-opening experience. Seated at the conference table in Bush's office was a distinguished group: Dr. James B. Conant, President of Harvard, the committee chairman; Dr. Lyman J. Briggs, director of the National Bureau of Standards; Dr. Eger V. Murphree, vice president of the Standard Oil Development Company; and three of the country's scientific greats, all Nobel laureates, Dr. Arthur H. Compton of Chicago University, Dr. Ernest O. Lawrence of California, and Dr. Harold C. Urey of Columbia. Getting down to business with these men, the Engineers discovered that nobody knew "just where we were."[11] Of the four bomb stuff processes, only electromagnetic separation, Professor Lawrence's baby, was anywhere near ready even for preliminary engineering development. Supplies of uranium and other vital materials were inadequate even for research, much less for production. No one as yet had a clear concept of what Marshall was to build. Nevertheless, all the scientists save Lawrence, who wanted a location close to his Berkeley laboratory, were anxious to acquire a large tract west of Knoxville as the main manufacturing site. After two sessions with the committee, Marshall agreed to go ahead, signing up contractors, procuring supplies, acquiring land, and using every available means to move the project forward.[12]

He made a promising start. A conclave with the Chief and his principal advisers set the Corps machinery in motion. Reybold and Robins gave the signal for "all out support from the Engineer Department at Large."[13] Groves offered to assist in every way he could. Stratton made available site planner Leon Zach, power specialist Carl H. Giroux, and water supply expert Ray E. Lawrence as consultants. Colonel Gesler in the Fiscal Branch agreed to track down funds. Colonel O'Brien in Real Estate promised swift action on land acquisi-

[9] (1) Marshall Diary, 19–24 Jun 42. (2) Ltr, Marshall to authors, 15 Jan 68. (3) Leslie R. Groves, *Now It Can Be Told: The Story of the Manhattan Project* (New York: Harper & Bros., 1962), pp. 11–12.

[10] Marshall Interv, 19 Apr 68. See also Marshall Diary, 26 Jun 42.

[11] Interv with Gen Kenneth D. Nichols, 18 Feb 64.

[12] (1) Min, Mtg of S–1 Exec Comm, 25 Jun 42. AEC Files. (2) Marshall Diary, 25 Jun 42. (3) Vincent C. Jones, Manhattan: The Army and the Atomic Bomb, draft manuscript in OCMH, ch. III, pp. 16–22.

[13] Ltr, Robins to authors, 12 Feb 64.

tion. Colonel Hall in Cincinnati and Colonel Worsham in Chicago alerted their division staffs to stand by for site directives. In Manhattan, Colonel Dunn rented space for the new district downstairs from North Atlantic Division headquarters and placed his organization at Marshall's disposal. Talks with Dr. Compton and other scientists clarified plans for leasing a thousand-acre tract in the Argonne Forest southwest of Chicago and building a plutonium pilot plant there and for subletting part of the heavy water plant at Trail to E. B. Badger & Sons of Boston. An all-day negotiating session on 29 June produced a letter contract with Stone & Webster. A visit next morning to General Clay had encouraging results: a friend and classmate of Marshall, Clay agreed to help obtain a high priority rating and to use his good offices in breaking procurement bottlenecks. At this point, Marshall and Nichols confronted a major decision—choice of the main manufacturing site. On the afternoon of the 30th, after a last-minute chat with Groves, they took the 5 o'clock train for Knoxville.[14]

Early the next morning they checked in at the Hotel Andrew Johnson, where they met four Stone & Webster men and Captain Blair. After a briefing by officials of the Tennessee Valley Authority (TVA), the party spent the better part of two days exploring the foothills of the Cumberlands west of Knoxville, looking for a spot that met their requirements: power, water, transportation, and special topography—"four isolated sites in one big isolated site," as Marshall put it.[15] Scouts for OSRD had been over the ground earlier and had sent back glowing reports. But, like all professional engineers, Marshall wished to be on the safe side. Jouncing over back country roads around Harriman, Dayton, and Athens, he ruled out several locales. One site was too rugged, another too remote, a third subject to flooding. Then, along the Clinch River southwest of the little town of Clinton and a few miles downstream from Norris Dam, he found it astride Roane and Anderson Counties—a hundred-square-mile rectangle of marginal farmland with a washboard terrain, an area of wooded ridges and lonely hollows. The population was sparse and real estate values were low. Watts Bar Reservoir was fairly close, and two railroads, the Louisville & Nashville and the Southern, ran nearby. There were some drawbacks, to be sure: outcroppings of rock foretold costly excavations; and TVA could promise adequate power only if it could procure additional hard-to-get generators. Somewhere, no doubt, there was a better location, perhaps in the Columbia River Valley near the Corps' own Bonneville Dam. Yet, on the whole, Clinton seemed a reasonably good choice.[16] Marshall headed back East, full of plans and purpose.

Nichols and Blair continued on to the Metallurgical Laboratory, the cryptically named center for plutonium studies at the University of Chicago. In two days there, they covered a lot of ground. Conferring with Dr. Compton and his

[14] (1) Marshall Diary, 26–30 Jun 42. (2) Interv with Gen James H. Stratton, 21 Feb 68.

[15] Marshall Interv, 19 Apr 68.

[16] (1) Marshall Diary, 1–3 Jul 42. (2) Hewlett and Anderson, *The New World*, pp. 76–77. (3) Arthur H. Compton, *Atomic Quest: A Personal Narrative* (New York: Oxford U. Press, 1956), pp. 154–55.

colleagues, they learned what the "Met Lab" was up against. Organized early in 1942 under Compton's direction, a team of eminent researchers was seeking a way to transmute uranium into plutonium on a large scale as quickly as humanly possible. Key to the success of this endeavor were the experiments of Enrico Fermi, the gifted Italian Nobel laureate who had fled Fascist tyranny in 1939. With uranium oxide and graphite, Fermi was struggling to build a chain reacting "pile." Theoretically, the pile would go critical when it reached a certain size, that is, it would chain react and in the process produce plutonium within the parent uranium. Chemistry would do the rest. "Any fool can separate two elements," Compton assured the Engineers.[17] But the theory of the pile still lacked a demonstration. Shortages of pure materials hampered Fermi's efforts. Moreover, he needed space; the University was crowded and, besides, the populous southside of Chicago was no place to be tinkering with chain reactions. Shouldering responsibility, Nichols marked out boundaries for the experiment station site in the Argonne Forest, arranged for Worsham to lease the land rent free from Cook County, and sketched preliminary construction plans for Stone & Webster.[18] He also took on the duty of providing wanted supplies. Most important, he got off on the right foot with Met Lab leaders. Describing what proved to be a happy and fruitful relationship, Compton later portrayed Nichols as "straightforward and courageous," "a man who really understood" the scientists' problems.[19]

Rejoining Marshall in Washington, Nichols and Blair were caught up in a surge of activity: working with Stone & Webster to tie together myriad loose ends (a detailed survey of the Tennessee site stood high on the agenda); insuring vital supplies of uranium ore (on orders from the Chief, Engineers in northwestern Canada sent barges to the Eldorado mine, near the Arctic Circle on Great Bear Lake); negotiating contracts for purified uranium oxide and uranium metal (the producers were the Mallinckrodt Chemical Works, Metal Hydrides, and Westinghouse Electric); planning a village for the main industrial site (Stratton's files yielded blueprints developed by the Corps for family housing at Ocala, Florida, and Passamaquoddy, Maine); furnishing the New York office and establishing a protective security system there (Vanden Bulck, with help from Colonel Dunn, quickly accomplished the job); pursuing a scheme to substitute silver for critically short copper in Professor Lawrence's process (thousands of tons of conductive metal would go into the giant coils and busbars); trying to think of a suitable cover name for the project (Somervell's suggestion, "DSM" for Development of Substitute Materials, satisfied virtually no one); and preparing a table of organization (Marshall expected to have 62 officers under his command by the end of the year).[20] For a time at least, all went well.

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[17] Nichols Interv, 18 Feb 64.

[18] (1) *Ibid.* (2) Marshall Diary, 6–7 Jul 42.

[19] Compton, *Atomic Quest*, pp. 95, 106.

[20] (1) Marshall Diary, 6–15 Jul 42, *passim.* (2) Groves, *Now It Can Be Told*, pp. 15–16. (3) Ltr, Marshall to Reybold, 18 Jul 42. 320.21 (Manhattan DO).

Then, in mid-July, the project received a setback: assignment of an AA–3 priority. To Marshall and Nichols, the news seemed incredible; surely, the S–1 effort rated higher than the Pennsylvania Ordnance Plant. But a talk with Clay convinced them that there had been no mistake. The atomic bomb was a long shot. Gambling on it too heavily might risk losing the war. Extremely urgent programs—airplanes, naval vessels, cargo ships, landing craft, synthetic rubber, and high-octane gasoline—were in desperate conflict for materials. Only essential weapons slated for early production could claim AA–1 and AA–2 priorities. The special triple-A rating was reserved for breaking bottlenecks. Under ANMB rules, AA–3 was the highest possible classification for plant construction jobs. Clay saw no reason for making an exception of DSM; in fact, he discouraged any move to upgrade the project. Deeply disappointed, Nichols consulted Reybold, who gave him this advice: let the issue ride awhile, wait for trouble to appear, and, then, launch a determined drive for top priority.[21]

If Marshall was downcast, his mood soon changed. Visiting the Radiation Laboratory of Professor Lawrence in the third week of July, he felt his spirits rise. High on a hill overlooking the Berkeley campus and San Francisco Bay, in a newly built domed structure, a mighty "calutron," a scaled-up adaptation of the California physicist's original cyclotron, was taking form. Its magnet, the world's largest, measured 184 inches in diameter and towered 20 feet above the floor. A C-shaped vacuum tank occupied the 72–inch pole gap. Enthusiastic and confident, Lawrence explained to Marshall how the apparatus would work: in the strong magnetic field, ions of uranium gas zipping through the vacuum at tremendous speeds would tend to separate according to mass, heavier particles describing longer arcs than lighter ones, and U–238 and U–235 ending up in different receptacles. Two smaller calutrons were already in operation. To be sure, their yield was minuscule and their product was highly impure; nevertheless, they were getting tangible results. A mass production plant patterned on this method would be extremely large and costly, but it would almost certainly succeed. When Lawrence spoke of trying to improve the process to effect economies, Marshall told him to "quit worrying about expense"—the Army would pay the tab. Summoning representatives of Stone & Webster, the colonel put them to work with the Berkeley scientists on preliminary plant designs. Encouraged, he noted in his diary: "Lawrence's method is ahead of the other three methods and should be exploited to the fullest extent without delay."[22]

Immediately upon his return to Washington, he asked for a gross appraisal of the Clinton site. O'Brien promised a rough estimate "about the middle of next week" and he was as good as his word. On 29 July he gave Marshall a cost breakdown. Eighty thousand acres at $30 per acre, plus improvements, crops, severance damages, and contingencies—the figures added up to approximately $4 million. Obtaining right-

[21] (1) Marshall Diary, 13 Jul 42. (2) Jones, MANHATTAN, ch. III, pp. 38–43. (3) Hewlett and Anderson, *The New World*, pp. 72–75 and 78–79.

[22] Marshall Diary, 20–21 Jul 42. See also Smyth, *Atomic Energy for Military Purposes*, pp. 139–41.

of-entry would take about ten days. Colonel Hall's real estate men were ready to start at once, but Marshall delayed giving them a green light until he could pin down the S–1 Executive Committee. Lawrence was insisting on a West Coast site for the big electromagnetic plant. Fermi's crucial experiment at Chicago was still months away. Gaseous diffusion and centrifugal separation had only theoretical feasibility. Before he laid out millions in public funds and uprooted hundreds of families, Marshall intended to have a fixed purpose in view.[23] The scientists wanted the Tennessee tract but could not say, specifically, what for. Recalling his ordeals with them, Marshall said: "When you get six or seven Ph.D.'s and three or four Nobel Prize winners around the table, you know, they are up in the clouds." Impatient, he told them "that if they didn't hurry up and make up their minds what they wanted to develop, we might not need a site; the war would be over." His sarcasm had no discernible effect.[24]

A darkening cloud of uncertainty overhung the project. Striving for an early start at Trail, Badger & Sons ran into trouble as work on components for the heavy water process stalled, while shops completed longer standing orders with the same AA–3 priority. Badger's case had disturbing implications, for, although Trail would be an auxiliary plant (its product was a possible substitute for graphite in the pile), its plight augured ill success for the whole atomic undertaking. Again and again, Marshall and Nichols tried and failed to wring a higher overall priority from General Clay and, through Bush and Conant, to enlist Donald Nelson's aid. Without full top-level support, all the projected plants could not be built in time to be of value in the war; and no such support was immediately forthcoming. Sensing that they might have to focus on a single process, the Conant committee deliberated, refusing to go all-out on Lawrence's method until Fermi's experimental results were in.[25] As planning bogged down in a morass of scientific indecision, Marshall endeavored to make headway in other areas.

Moving to Manhattan, he began shaping his command. By early August staffing was in full swing. A dozen officers in the Syracuse District were awaiting orders to join their former chief and various hand-picked civilians were preparing to take commissions in the Corps. A versatile group formed the nucleus of the new district. Among the men drawn from Syracuse were Lt. Col. John M. Harman, a Regular with 24 years' service; Maj. Thomas T. Crenshaw and Capt. Joseph F. Sally, both successful area engineers on big emergency projects; Capt. James F. Grafton, a crack operations man who had overseen construction of the Whitney Point Dam near Binghamton, N.Y.; Capt. Benjamin K. Hough, Jr., a keen-minded soils engineer who had studied under Terzaghi at MIT; and 1st Lt. Harold A. Fidler, a young D.Sc. from MIT who had worked with Hough at

[23] (1) Marshall Diary, 23, 24, and 31 Jul and 3 Aug 42. (2) Apps. of Site Sel and Land Acq for CEW, 15 Jun 45, Exhibit F–1. 601.1 (CEW). (3) Min, Meeting of S–1 Exec Comm, 30 Jul 42. AEC Files. (4) Nichols Interv, 18 Feb 64.

[24] Marshall Interv, 19 Apr 68.

[25] (1) Marshall Diary, 17 Jul–26 Aug 42, *passim*. (2) Hewlett and Anderson, *The New World*, pp. 78–81.

the Ithaca Soils Laboratory. The search for talent extended well beyond the Mohawk and Susquehanna watersheds. With assists from General Reybold and William H. Harrison, Marshall was able to recruit Wilbur E. Kelley, senior engineer for the Panama Canal, and Allan C. Johnson, a highly trained architect on loan to WPB from the American Telephone and Telegraph Company, and to make them both captains in the Corps. Another valuable find was Capt. John R. Ruhoff, the Mallinckrodt Company's brilliant young director of inorganic research, recently called to duty with the Chemical Warfare Service and shortly to be transferred to the Engineers. As the ranks started to swell, Marshall moved to place the organization on a firm footing.

On 16 August 1942 General Reybold formally established the Manhattan Engineer District (MED).[26] Selected by Groves and Marshall, the tag word "Manhattan" provided an effective cover, since ordinary Engineer districts took the names of their headquarters cities. Judged by Corps standards, the new supersecret setup was unusual. Unlike other districts, MED had no geographic boundaries and its areas were far apart: at Boston, Chicago, St. Louis, Berkeley, and Trail. Alone among district heads, Colonel Marshall had the authority of a division engineer and reported directly to the Chief. Another peculiar feature was the Washington Liaison Office, opened on the sixth floor of the New War Building to ensure concerted action with WPB, SOS, and other high-level agencies. Carefully matching men and duties, Marshall appointed Harman his administrative officer, put Kelley in charge of engineering, and gave Johnson the Washington assignment. In addition, he sent Crenshaw and Fidler to the Radiation Laboratory, Grafton to the Met Lab, Hough to Stone & Webster's hometown, Boston, and Sally to British Columbia. As head of the St. Louis office, Ruhoff carried on his vital work at the Mallinckrodt plant.[27] Still small but growing steadily, the Manhattan District was a going organization by late August.

After reading the first progress report from MED on 26 August, Reybold expressed his satisfaction with the project. Since mid-June the atomic program had come a long way. At Berkeley, Stone & Webster had completed blueprints for an electromagnetic pilot and construction was all set to go. At Chicago a Met Lab building was rising on the University campus and survey crews were busy at the Argonne Forest site. Although pinched for materials, the job at Trail was moving ahead. Even at Columbia, where Urey and his colleagues had still to work out kinks in the gaseous diffusion and centrifuge processes, construction plans were beginning to take form. Two major supply problems were clearing up: Marshall was about to close a deal with the Treasury for some 6,000 tons of silver; and Nichols was in touch with Edgar Sengier, a far-sighted Belgian mining magnate, who had 1,250 tons of Congo uranium ore cached in a warehouse on Staten Island. Marshall was prepared

[26] Officially: Manhattan District, U.S. Engineer Department.

[27] (1) OCE, GO 33, 13 Aug 42. (2) MED Circ Ltr A-1, 16 Aug 42. 323.7 (MDO). (3) Ltr, NAD to Reybold, 8 Aug 42, 210.3 (MDO). (4) MED SO 1, 21 Aug 42.

to break remaining logjams. Fed up with academic shilly-shallying, he recommended immediate acquisition of at least part of the Tennessee tract. Tired of taking no for an answer on priorities, he proposed to go over Clay's head.[28]

Achievements drew less notice from Dr. Bush than things left undone. Haunted by the fear that Hitler was winning the contest for the bomb, the OSRD chieftain was intolerant of delay. Apprehensive about the Tennessee site and the MED priority, he mistook deliberation for foot dragging and prudence for passivity. Feeling that the project needed more aggressive leadership and more effective status in the Army, he discussed with Generals Marshall and Somervell and others the formation of a policy committee that would command respect, a body composed of high-placed military men and eminent civilian scientists; and he spoke of appointing a prestigious officer, preferably Styer, as overall director. When Somervell mentioned Groves as the right man for this post, Bush cold-shouldered the suggestion. So uncertain, so precarious, yet so fraught with awesome possibilities, the atomic effort undoubtedly needed a strong hand and a resolute will to lead and guide and push it through. Bush intended to take one step at a time: first, choose the committee and, then, name the general to carry out its will.[29] But Somervell, adroit as ever, outmaneuvered him.

The week of 13 September was a decisive one for MED. Meeting at scenic Bohemian Grove near San Francisco, the S–1 Executive Committee put an end to much of the uncertainty that had surrounded the project. Urged on by Nichols and Crenshaw, who attended as observers, the scientists voted to center production at the Tennessee site, make a prompt beginning there, and push plans to break ground for the big electromagnetic plant around the first of the year.[30] In Washington, meanwhile, another major decision came to light. Emerging from a Thursday morning session with the House Military Affairs Committee, Groves bumped into Somervell, who told him: "The Secretary of War has selected you for a very important assignment . . . . If you do the job right, it will win the war." Groves, whose heart was set on going overseas, blazed with indignation, for he guessed correctly that the job involved "that thing," the atomic bomb[31]—a "pipe dream," as he saw it, with little chance of fulfillment. Reporting to Styer at the Pentagon later that morning, he received some rosy promises: a promotion, an easy task (merely to build a few plants), and virtual independence.[32] Unmollified, he reproached Styer for "letting me get hooked into this."[33] Then, unheralded, he called on Bush, who froze as the burly colonel introduced himself. Groves' stock soon rose. Good soldier that he was, he zealously obeyed his duty. Before the week was over, he had given the go-ahead on the Ten-

[28] (1) Marshall Diary, 26 Aug 42. (2) Marshall Interv, 19 Apr 68.

[29] (1) Hewlett and Anderson, *The New World*, pp. 81–82. (2) Nichols Interv, 18 Feb 64.

[30] (1) Min, Mtg of S–1 Exec Comm, 13–14 Sep 42. AEC Files. (2) Marshall Diary, 13–14 Sep 42. (3) Compton, *Atomic Quest*, pp. 150–54.

[31] *Now It Can Be Told*, pp. 3–4.

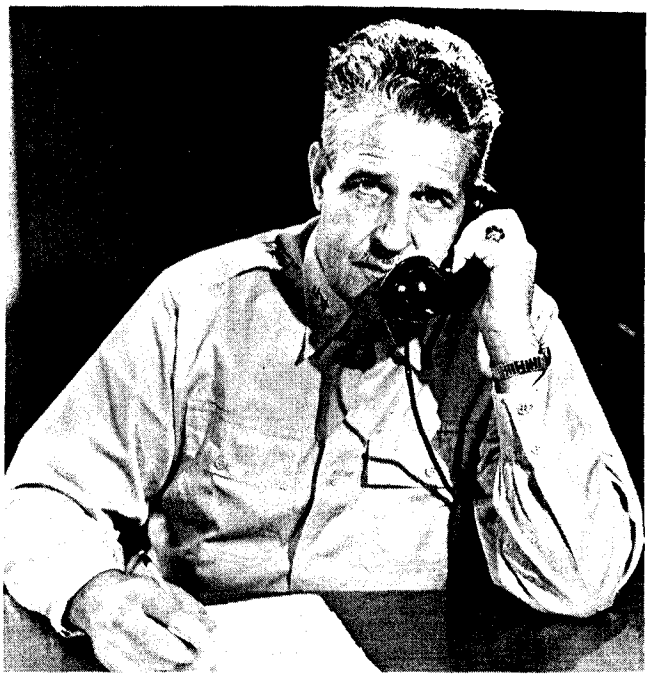
[32] Interv with Gen Groves, 28 Apr 67.

[33] Leslie R. Groves, "The Atom General Answers His Critics," *The Saturday Evening Post*, June 19, 1948, p. 16.

nessee tract and inveigled Donald Nelson into granting him power to assign triple-A priorities.[34]

Groves waited until 23 September, when he received his brigadier's star, before he assumed command. He understood rightly that a general could speak more convincingly than a colonel even to civilian scientists.[35] But mere rank did not account for the change in administration which resulted from his appointment. Groves' intrinsic qualities—his toughness, courage, and perspicacity—were far more significant. With exemplary self-discipline he gave every ounce of energy to a task which seemed as unrewarding as it was full of risk and all but impossible of accomplishment, and he expected no less of subordinates. He was often brusque and uncompromising, "ornery" by his own admission, a "brass hat" and a "stinker" in other people's words.[36] He little cared what was said about him. He was fighting to end a war, and he had a vivid appreciation of the personal consequences of failure. "The President has selected me to carry the ball, which is another way of saying that I am to be the Goat if it doesn't work," he told an MED colonel. "If our gadget proves to be a dud, I and all of the principal Army officers of the project . . . will spend the rest of our lives so far back in a Fort Leavenworth dungeon that they'll have to pipe sunlight in to us."[37]

Just as MED was unique as an Engineer district without territorial limits, so General Groves was unique as an Army officer without clear-cut status in the chain of command. On the face of it, Somervell's order to Reybold to release Groves for special duty with the DSM project seemed explicit: "He will report to the Commanding General, Services of Supply, for necessary instructions, but will operate in close conjunction with the Construction Division of your office and other facilities of the Corps of Engineers."[38] But Groves, who helped draft the order, dismissed this wording as "eyewash." "Initially," he commented, "General Somervell seemed to think that I would be under the SOS. This was never straightened out on paper. I never thought he wanted me



GENERAL GROVES AS HEAD OF THE MANHATTAN PROJECT

[34] (1) Groves, *Now It Can Be Told*, pp. 20–23. (2) Hewlett and Anderson, *The New World*, p. 82.

[35] (1) Groves Interv, 11 Feb 64. (2) Groves, *Now It Can Be Told*, p. 5.

[36] (1) Groves Interv, 27 Apr 67. (2) Antes Interv, 3 Jun 58. (3) Deland Interv, 5 Jan 68.

[37] Col Gerald R. Tyler, Résumé of Instructions from Gen Groves, Oct 44. Tyler Papers.

[38] Memo, Somervell for Reybold, 17 Sep 42. MED Files, MP Folder 25B.

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to be under the Chief of Engineers. He wanted me to run the thing and he didn't want anyone to interfere with me in any way." No one challenged Groves' interpretation. Among the high-ranking officers in the War Department, there was much fear that the project would absorb funds and materials in great amounts and then fail in its objective; and from this fear stemmed a growing desire not to be entangled. Somervell evidently looked upon the project as a hot potato more or less safely disposed of in Groves' hands, that is, handed to a man of steady nerves not likely to drop it. Reybold greeted the new arrangement with undisguised relief. Frankly sympathetic, Robins told Groves: "I hate to see you get this assignment, because if you fail in it, it will destroy you. I would be sorry to see that. But it would be still worse if it destroyed the Corps of Engineers. That would really make me sad."[39] Groves, an officer never reluctant to assume responsibility, now had it in abundance.

He also had abundant counsel and support. On 23 September, the same day Groves officially assumed command, the President's top atomic advisers created the Military Policy Committee, with Bush as chairman, Conant as his alternate, and two service members: Rear Adm. William R. Purnell, Assistant Chief of Naval Operations, and General Styer. This group formed a bond with the MED commander not unlike that of a corporation board with a chief executive officer. Some months later, recognizing the need for consultants who would demonstrate to the scientists that he had competent advice, Groves appointed Conant and Dr. Richard C. Tolman, graduate dean of the California Institute of Technology, to his immediate staff.[40] Throughout the life of the project, co-operation and cordiality characterized the relations of top scientists and top military men; what misunderstanding there was, and at times there was considerable, developed in the middle and lower echelons. The resources of the whole defense establishment were available to MED, and Groves exploited them methodically. The Medical, Signal, and Transportation Corps, Army Intelligence, and Naval Ordnance, all contributed significantly to the realization of the bomb. But by

[39] Groves Interv, 11 Feb 67. See also Marshall Diary, 19 Sep 42; Ltr, Robins to authors, 12 Feb 64; and Ltr, Styer to authors, 12 Feb 68.

[40] (1) Smyth, *Atomic Energy for Military Purposes*, pp. 59–60. (2) Groves, *Now It Can Be Told*, pp. 24–25 and 44–45.

far the most massive contribution came from the Engineers. Construction was the central task, and the Corps' construction capability had never been greater. Men, money, machinery, materials, wide-ranging technical and administrative services—"Everything we wanted, we got," Groves related, "and we got it willingly."[41] A distinctive feature of MED was its "very limited organization," a feature that evidenced the firm support provided by the Engineer Department.[42]

An admirer of General Sherman, Groves believed in traveling light, and he held with Sherman that "a small staff implies activity and concentration of purpose." From a modest, sparsely furnished suite on the fifth floor of the New War Building, he steered the vast atomic endeavor almost single-handed. His principal assistant was his girl Friday, Mrs. Jean M. O'Leary. Saluted good-humoredly as Major O'Leary by MED wags, the pretty, spunky widow was his de facto executive officer. Not until early 1945, when General Farrell returned from CBI, did Groves have a deputy. Aided mainly by Mrs. O'Leary and a few picked men drawn from the Construction Division, he played what he described as the impresario's role in "a two-billion-dollar grand opera with thousands of temperamental stars in all walks of life." The story was epic and the stage was worldwide. Limited at first to plant construction and engineering, Groves' responsibilities rapidly ballooned to take in security and press censorship, intelligence and counterintelligence, all scientific research, and design of the weapon itself, and eventually encompassed matters of international relations, high-level policy, and atomic strategy. Much of his time was taken up by "numerous, all-important decisions, seemingly insuperable problems and fantastic controversies."[43] His account of MED, *Now It Can Be Told*, focused largely on these. "The bulk of the project," he wrote, "moved ahead by dint of the hard work and the feeling of urgency of everyone concerned and without requiring any personal supervision on my part."[44] Construction, which accounted for roughly 90 cents of every dollar spent, received comparatively little space in his book.

The fall of 1942 witnessed lively activity in the Clinch River Valley of Tennessee. On 24 September, the day after Groves formally assumed command, he and Marshall made a thorough, final reconnaissance of the site. Four days later an attorney from the Ohio River Division opened an office in Harriman and began mapping the area. On 6 October he filed a declaration of taking with the Federal Court at Knoxville and obtained immediate possession. Like virtually all mass condemnations, this one caused a furor—protest meetings, appeals to Washington, and congressional inquiries. Acquisition proceeded all the same. "Really child's play," Marshall termed it.[45] By mid-November U.S. marshals were tacking notices to vacate on farmhouse doors, and within a week

[41] Groves Interv, 11 Feb 64.
[42] Leslie R. Groves, "Development of the Atomic Bomb," *The Military Engineer*, June 1946, pp. 233–34.
[43] Groves, "The Atom General," p. 16.
[44] Groves, *Now It Can Be Told*, pp. xiii–xiv.
[45] Marshall Interv, 19 Apr 68.

or two residents were leaving.[46] Construction crews came in right behind them. On the scene since October the area engineer, Maj. Warren George, and Stone & Webster's project manager, T. Cortlandt Williams, were set for a fast start. Key men were arriving daily. Materials were on order. An employment office in downtown Knoxville was open for business. From the contractor's Boston headquarters plans and blueprints were flowing to the project. At the Chief's office in Washington Colonel Barker was pressing for prompt wage determinations and General Robins was circularizing the Corps for surplus equipment, supplies, and personnel. Late in November dirt began to move. Before long construction forces were spreading out to provide temporary utilities, improve primitive roads, run a rail connection to the Louisville & Nashville at Elza, and erect the project's first big structure, the main administration building.[47]

Even before a spade was turned at Clinton, the Engineers were moving toward their ultimate objective, the weapon itself. Late in October 1942, a Regular with the Syracuse District, Maj. John H. Dudley, received a special assignment, "to make a survey for an installation of unnamed purpose."[48] His orders, signed by Marshall, specified a partly developed site surrounded by hills in a thinly settled area of the southwest, where a community of 250–450 persons could live in isolation. His mission was the outgrowth of conversations between Groves and Dr. J. Robert Oppenheimer, the young Berkeley professor who spearheaded studies of the physics of the bomb. "The first job was to make the stuff," Oppenheimer related. "But in hope that would come out all right, we had to have a place where we could learn what to do with it."[49] After traveling thousands of miles, part of the way on horseback, consulting district engineers along his route, Dudley narrowed the search to the Santa Fe area. On 16 November he showed Groves and Oppenheimer a spot that fitted their stated criteria: Jemez Springs, a village of 500 on the floor of a canyon in the Jemez Mountains. Oppenheimer promptly objected that the tall surrounding cliffs "would give his people claustrophobia," and the houses, simple Indian and Mexican dwellings, would be too humble for them; while Groves noted that the site might be subject to flooding. The party then drove east and on up a steep, narrow dirt road to the exclusive Los Alamos Ranch School. On a mesa jutting out from the Jemez Mountains and overlooking the upper Rio Grande Valley, the 790-acre site was impressive in its solitude and scenic grandeur. The attractive campus, with its log and stone buildings and well-kept grounds, offered comforts and amenities taken for granted by the well-to-do. Oppenheimer indi-

[46] (1) Marshall Diary, 24 Sep 42. (2) Groves, *Now It Can Be Told*, pp. 25–26. (3) Apps. of Site Sel and Land Acq for CEW, 15 Jun 45. 601.1 (CEW). (4) 601.1 (CEW) Parts 1 and 2. (5) H Subcomm of the Comm on Mil Affs, Transcript of Hearings at Clinton and Kingston, Tenn., 11–12 Aug 43. 601.1 (CEW).

[47] (1) Gavin Hadden (comp.), Manhattan District History, Book I, Vol. 12. AEC Files. Cited hereinafter as MD Hist. (2) Hewlett and Anderson, *The New World*, pp. 116–17. (3) Ltr, Marshall to George, 21 Oct 42. 161 (MDO). (4) Ltr, Robins to Div Engrs, 20 Nov 42. 600.1 (MDO). (5) 600.1 (MDO) (Labor) Part 1.

[48] Ltr, Dudley to authors, 5 May 68.

[49] Oppenheimer's Testimony, 12 Apr 1954. In U.S. Atomic Energy Commission, *Hearings in the Matter of J. Robert Oppenheimer* (Washington, 1954), p. 28. Cited hereinafter as AEC, *Oppenheimer Hearings*.

cated that this was it. Groves and Dudley put their heads together. Except for the road, the setup seemed ideal: the owners were anxious to sell; the water supply was adequate for 500 people; and there was plenty of room for expansion. They made their selection then and there.[50]

Speed was the byword at Los Alamos. Responding to a signal from the Chief's office, the Albuquerque District snapped into action. Zia Project, named, fittingly enough, for the Sun God of the Pueblo Indians, promptly claimed the services of engineers, appraisers, and attorneys. By 21 November early reports were in. On the 23d the district engineer, Col. Lyle Rosenberg, obtained right-of-entry. Hand carried from Robins to Somervell to Patterson on the 25th, the formal site directive gave Colonel Neyland of the Southwestern Division authority to acquire the ranch school and environing forest and grazing lands—54,000 acres in all. Signed by Groves as Robins' deputy, a title he continued to use until mid-1943, the work directive came out on the 30th. Five days later Rosenberg awarded a secret contract to the M. M. Sundt Construction Company of Tucson. Sundt's deadline was short: a scientists' enclave, complete with dwellings and laboratories, fenced and tenanted by mid-May.[51] This schedule reflected the urgency that surrounded the project, the pressure, which Oppenheimer noted, "started at the beginning and never let up."[52] The need for haste was keenly felt by General Groves. Although leading scientists thought of putting a bomb together as a few months' work, Groves, thinking as an engineer, took nothing for granted: the widest possible margin of safety might not be wide enough.[53]

For all their brilliance, the academic scientists often seemed naive and impractical to hardheaded military engineers. As theorists "they were wonderful," Colonel Marshall said; but as doers he rated them low.[54] Nichols, who agreed with Marshall, chuckled over the scientists' self-esteem. One day, on a visit to Chicago, he found Fermi's group speculating how to design concrete, how to keep the water content in. "This was typical," he commented. "It's true of most scientists. They're outstanding and they are geniuses in one aspect, so they think that in every other aspect, in every other trade or profession, they can be equally proficient if they only try."[55] Groves, on entering the project, was appalled—"horrified" was his word—by the visionary nature of the enterprise. An all-round lack of concrete results, postulates taken as truths, key calculations accurate to a factor of 10, mistakes in simple mathematics—impressions gained on a tour of the laboratories spurred him to action.[56] Deciding to "wash out" the centrifuge ("We didn't know whether that would ever work,"

[50] (1) *Ibid.*, pp. 12 and 28. (2) Ltr, Dudley to authors, 5 May 68. (3) Groves, *Now It Can Be Told*, pp. 61 and 64–67.

[51] (1) Jones, Manhattan, ch. IV, pp. 28–31 and ch. VII, pp. 36–39. (2) 601.1 (Los Alamos, N.M.–Zia Project). (3) Ltr, Robins to Somervell, 25 Nov 42, and Patterson's approval thereon. MED Files. 601 (Santa Fe). (4) Ltr, Groves to Rosenberg, 30 Nov 42. MED Files. 600.1 (Santa Fe) thru 1944.

[52] AEC, *Oppenheimer Hearings*, p. 30.

[53] (1) Stephane Groueff, *Manhattan Project: The Untold Story of the Making of the Atomic Bomb* (Boston: Little, Brown & Co., 1967), pp. 41–42. (2) Groves, *Now It Can Be Told*, p. 60.

[54] Marshall Interv, 19 Apr 68.

[55] Nichols Interv, 18 Feb 64.

[56] (1) Groves, *Now It Can Be Told*, pp. 19 and 40. (2) Groves Interv, 27 Apr 67. (3) Groueff, *Manhattan Project*, pp. 17–39.

Marshall related), Groves favored bold assaults on the other processes. "We just can't wait for these people to perfect things," he and Marshall told Bush. "We have got to go ahead and build something and work out the details as we build it." The Engineers turned instinctively to industry for help.[57]

Groves knew which firms he wanted and he got them. To design, build, and operate the plutonium works, he picked DuPont, a company with a flawless record on Army munitions projects. As design consultant to Stone & Webster and operator of the electromagnetic plant, he chose Tennessee Eastman, the Kodak subsidiary which had masterminded the Holston Ordnance Works. For the gaseous diffusion process, he selected two highly reputable concerns, the M. W. Kellogg Company as architect-engineer and the Union Carbide and Carbon Corporation as operator. None of the manufacturing firms welcomed the assignment. "Why pick on us?" three vice presidents of Union Carbide asked Groves and Marshall.[58] DuPont officials were especially reluctant. Their forte was chemistry, not physics. Besides, they had their corporate image to consider. Association with a horror weapon would do their reputation no good. What's more, the odds were long, and they wanted no part of a fiasco. Equating consent with patriotic duty, Groves refused to take no for an answer. Primarily to reassure DuPont executives, who felt that the pile process was the least likely to succeed, Groves appointed a committee, headed by Dr. Warren K. Lewis, distinguished professor of chemical engineering at MIT, to evaluate the prospects of the various methods. As luck had it, the committee visited Chicago on 2 December 1942, the day Fermi gave his clinching demonstration—the first self-sustained nuclear chain reaction.[59]

Selling DuPont to the project was as difficult as selling the project to DuPont. Word that the company was taking over roused the Met Lab to near-mutiny. With a strong parental feeling toward their brainchild and an almost total blindness to engineering problems, the scientists wished to take the pile all the way themselves.[60] On visits to Chicago, Groves heard pleas to keep industrialists out.[61] Recalling a Met Lab roundtable, Nichols told a revealing story:

> I can remember Enrico Fermi protesting: "We don't need this great organization; they are too conservative. If you people will just hire for me the laborers and supply them with brick, I'll tell them where to lay it." Enrico Fermi was one of the greatest brains in the history of the world and that was a statement he made. I remember later going over to Arthur Compton, and Arthur said: "Sometimes, you know, I'm inclined to agree with Fermi. If we just had somebody to design the waterworks and roads, I think I'd almost be willing to back him." I said: "Well, Arthur, I'm a hydraulics expert and I have built a lot of roads and runways. I can design the waterworks and the roads. Let's do it." Then he started to laugh. He kept his feet on the ground. He was a great man, but he wanted us to listen to him.[62]

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[57] (1) Marshall Interv, 19 Apr 68. (2) Interv with Gen Groves, 11 Dec 69. See also Memo, Groves for Rcd, 11 Nov 42. MED Files. 334 (Committees).

[58] Groves Interv, 11 Feb 64.

[59] (1) Nichols Interv, 18 Feb 64. (2) Ltr, Compton to Conant, 23 Nov 42. MED Files. 334 (Committees). (3) Groves, *Now It Can Be Told*, p. 52.

[60] (1) Compton, *Atomic Quest*, pp. 164–65. (2) Groves, *Now It Can Be Told*, pp. 43–44. (3) Memo, E. P. Wigner for Compton, 7 Jan 44. MED Files. 319.1 (Rpts).

[61] Groves Interv, 27 Apr 67.

[62] Nichols Interv, 18 Feb 64.

Perturbed by DuPont's lack of enthusiasm, Compton suggested that a combination of General Electric and Westinghouse might be a better choice.[63] But Groves' decision was firm. "I wasn't interested in somebody who was enthusiastic," he explained, "I was interested in somebody who could do the job."[64]

A hunt for a second manufacturing site followed the hiring of DuPont. A talk with company president Walter S. Carpenter, Jr., confirmed Groves' own misgivings about putting the big plutonium works at Clinton. The chance that a nuclear reactor might explode, wreck the separation plants, and poison the air of Knoxville, thus destroying all security and forestalling further work on atomic energy—these thoughts impelled him to look elsewhere. Meeting at Wilmington on Monday, 14 December, DuPont officials, Met Lab scientists, and Corps representatives defined the site criteria: a 700-square-mile tract in a sparsely settled area with abundant power and water and year-round construction weather. Named by Groves to head the survey team was Maj. Franklin T. Matthias, a 34-year-old Engineer Reservist whose good work in the construction program had attracted the general's attention. Moving on the double, Matthias spent Tuesday arranging for DuPont men Gilbert P. Church and Albert E. S. Hall to join in the search and conferring with site and power specialists, principally General Robins and Mr. Giroux. All signposts pointed west toward the great hydroelectric dams, Boulder, Shasta, Grand Coulee, and Bonneville. After a day of preparation, the party left on Wednesday evening for Spokane.[65] Messages from OCE had paved the way. Impressed by the ready response, Matthias commented:

> A few telephone calls, a description of what we were looking for and every District and Division office in areas where a favorable site . . . seemed possible went to work . . . . They knew not why the site was needed, but they were told what was needed, and with their detailed knowledge of their District or Division were able to save us endless hours of investigation when any wasted time could result in a longer war or more lost lives.

On 31 December the three men turned in their report: near the village of Hanford, Washington, not far from Bonneville and Grand Coulee, they had found an almost perfect site.[66]

Bigger and bolder than scientific dreams, the atomic program crystallized in late 1942. Full-scale electromagnetic and gaseous diffusion plants plus a plutonium semiworks at Clinton; a complex of nuclear reactors and chemical separation plants at Hanford; camps for construction workers and towns for operating personnel at both main production sites; three heavy water plants in addition to the one at Trail; and Los Alamos, the wizards' workshop in the mountains of New Mexico: these were its major facets. The estimated cost was half a billion dollars. The target date for turning out the first bomb was sometime

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[63] Ltr, Compton to Conant, 23 Nov 42. MED Files. 334 (Committees).

[64] Groves Interv, 11 Feb 64.

[65] (1) Groves, *Now It Can Be Told*, pp. 68–74. (2) Groueff, *Manhattan Project*, pp. 128–30. (3) Col F. T. Matthias, Notes on the Hanford Engineer Works Project, May 1960. EHD Files.

[66] Ltr, Matthias to authors, 28 Apr 64.

in late 1944 or early 1945.[67] It was a desperate undertaking, fraught with perils and uncertainties. Contrary to all industrial experience, the plan made no provision for pilot plants. "With everything else the Corps built in the way of munitions plants," Marshall emphasized, "you would have a pilot plant until you perfected the process. But not in the Manhattan District."[68] So raw was the concept of gaseous diffusion that no one as yet knew how to make the barriers or porous membranes that were the very heart of the process. "Nothing like this had ever been attempted before," Groves reflected, "but with time as the controlling factor we could not afford to wait to be sure of anything. The great risks . . . simply had to be accepted."[69]

The chance that Hitler's Germany might gain the nuclear prize prompted the attempt and justified the risks. Mindful that the fate of mankind hung in the balance, President Roosevelt at the turn of the year committed the nation unreservedly to a concentrated drive for the bomb.[70]

Clinton and Hanford

To design and build the great manufacturing complexes in the States of Tennessee and Washington was, as Groves styled it, "the most exacting construction job of the entire war."[71] Vast, complicated, and supremely urgent, the task called for exceptional feats of engineering, organization, and management. To create a new industry normally took many years. From test tube to mass production, the development of nylon had spanned a decade; yet the nylon process was simple compared with any for fissionable materials. According to informed estimates, the electromagnetic plant at Clinton "in peacetime would easily require 10 to 15 years";[72] yet this was but one of three major plants undertaken by the Manhattan District. Together, the Clinton and Hanford Engineer Works comprised the largest crash construction job in history. Under the compelling stimulus of war, a generation of effort was compressed into a period of little more than two years.[73]

With remarkable swiftness, the peaceful, rural Clinch River Valley of Tennessee was transformed into a mammoth construction project, dusty, noisy, and pulsing with activity. Early in 1943 bulldozers swept through the area, clearing trees, demolishing sheds and shanties, and cutting broad roadways where narrow country lanes had served. In the northeast corner of the reservation, on the slopes of Black Oak Ridge, laborers battered subsurface rock to trench sewer and water lines for a residential community. To the south in East Fork Valley, alongside a new four-lane turnpike, carpenters erected plywood huts to house construction workers. Still farther south, beyond the crest of Pine Ridge, in the meadowlands of Bear Creek Valley, sur-

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[67] (1) Memo, Groves for Rcd, 11 Nov 42. MED Files. 334 (Committees). (2) Memo, Conant for Groves, 9 Dec 42. Same File. (3) Compton, *Atomic Quest*, p. 145.

[68] Marshall Interv, 19 Apr 68.

[69] Groves, *Now It Can Be Told*, p. 72.

[70] Hewlett and Anderson, *The New World*, pp. 114–15.

[71] Groves, "The Atom General," p. 16.

[72] Thomas R. Thornburg, *et al.*, "Men and Materials for a $427,000,000 Job," *ENR*, December 13, 1945, p. 126.

[73] Unless otherwise indicated the following section is based on MD Hist, Books II and IV.

veyors staked out base lines for the great electromagnetic plant. Some six miles to the southwest, on the Bethel Valley Road, work gangs prepared the site for the plutonium semiworks. On the low ground of neighboring Happy Valley, near the spot where Poplar Creek flowed into the Clinch, engineers scanned a 5,000-acre tract with a view to building the gaseous diffusion plant there. (*Map 4*) Although no earth would move in Happy Valley for several months, mid-winter groundbreakings at other points in the Clinton site marked the opening of what would be one of the stiffest battles of the war.

Directing field operations were four organizations, each with an arduous mission to perform. Having general oversight of the entire project was MED's Tennessee Area, headed by Lieutenant Colonel George. Trained in two professions, engineering and law, George relied initially on a small, close-knit staff: Maj. Paul F. Rossell (Engineering); Capt. Samuel S. Baxter (Town Planning); Capt. Thomas J. Rentenbach (Procurement); and several others. Except Baxter, an official of the Philadelphia Public Works Department until the war, all were former Corps employees. Carrying major managerial responsibility was Stone & Webster's project force under Cortlandt Williams. An able, dedicated construction man, associated with the firm since 1923, Williams pulled in seasoned experts from other company jobs. Headquartered briefly at the Hotel Andrew Johnson, George and Williams soon took over a large converted garage in downtown Knoxville. Two smaller groups, arriving later, set up shop at the site. DuPont's James D. Wilson, in charge of building the semiworks, had his office in an abandoned school; and John O. Merrill, whose architectural firm, Skidmore, Owings & Merrill, had been selected in February to design the community, had his in a deserted farmhouse. The other teams continued working out of Knoxville until 15 March, when the project's main administration building, dubbed "The Castle," was ready for occupancy. By then, construction was well under way.[74]

From the window of his office in the Castle, Colonel George could view a fair-sized city in embryo. Red brick chimneys brightened the woods on Black Oak Ridge; and freshly dug foundations in East Fork Valley marked the sites of apartment houses, dormitories, eating places, commercial buildings, schools, a hospital, a theater, a post office, a firehouse, and a police station. Begun by Stone & Webster and carried forward by Skidmore, Owings & Merrill, the master plan for town development showed originality and skill. Roads and streets followed winding routes along natural grades, reducing cuts and fills and adding charm and grace. Clusters of stores and supermarkets with large adjoining parking lots were prototypes of the shopping centers that would dot postwar America. Cafeterias outfitted with Automat equipment would feed 2,000 diners per hour. Structural designs were streamlined and distinctive. Believing that high-class quarters were essential to attract high-caliber people, Colonel Marshall insisted that every

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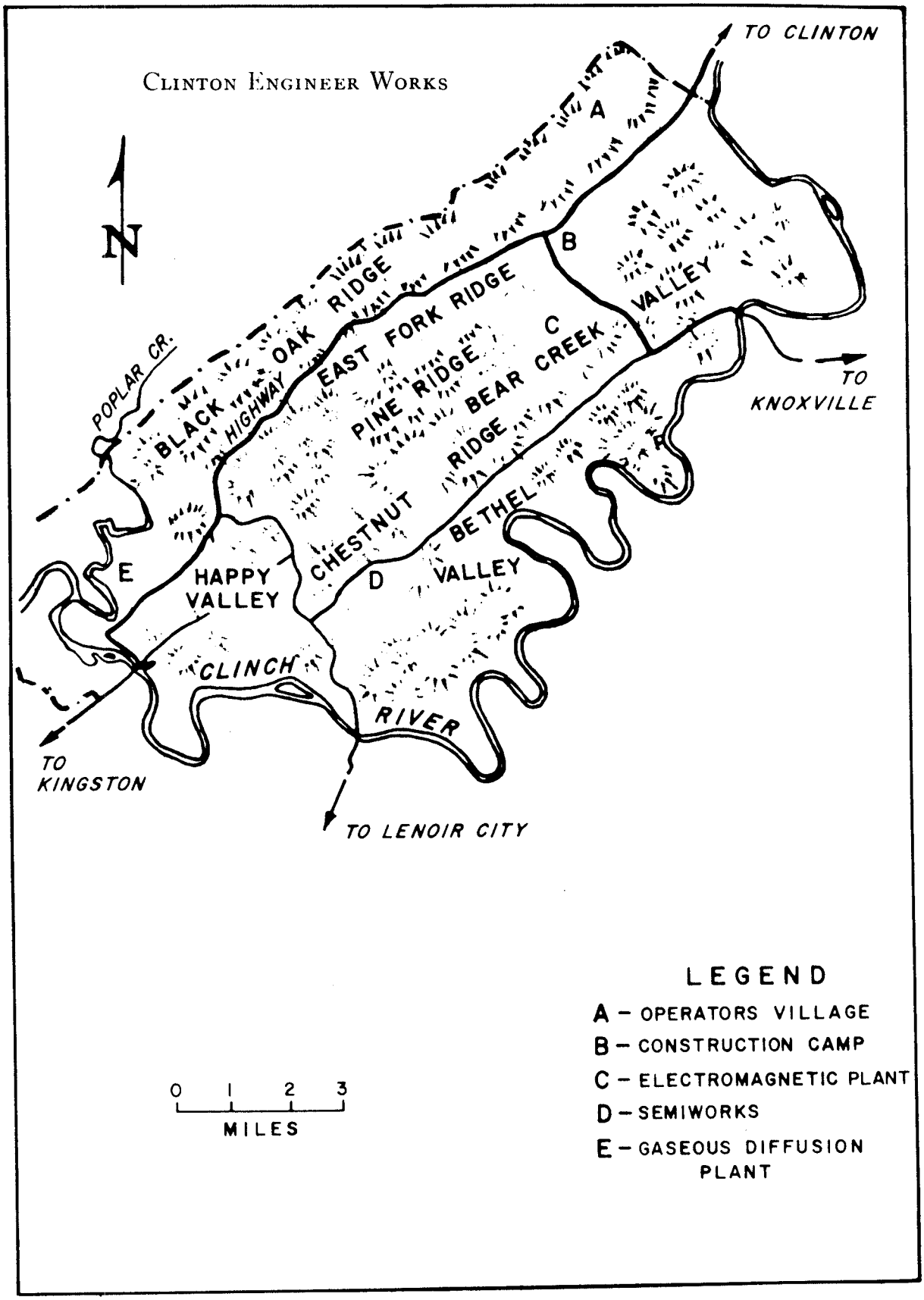
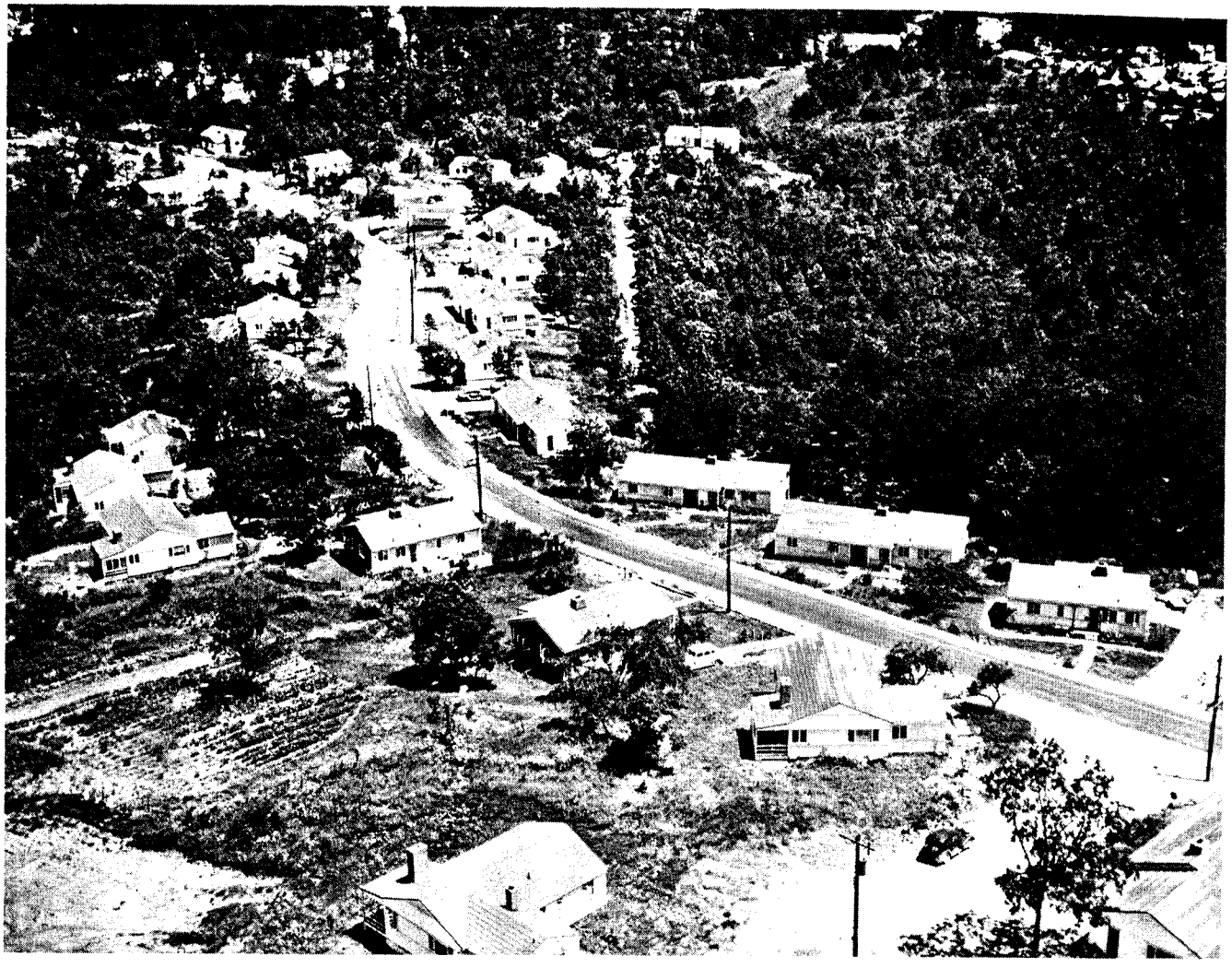
[74] (1) Intervs with Thomas J. Rentenbach, 21 Nov 68; and T. C. Williams, 26 Sep 68. (2) William J. Nash and O. L. Persechini, "The First 1,000 Days," *Monsanto Magazine*, February 1946, p. 5. (3) Groueff, *Manhattan Project*, p. 165.


CLINTON ENGINEER WORKS
N
TO CLINTON
A
B
C
D
E
BLACK OAK RIDGE
HIGHWAY
EAST FORK RIDGE
PINE RIDGE
BEAR CREEK VALLEY
CHESTNUT RIDGE
BETHEL VALLEY
HAPPY VALLEY
POPLAR CR.
CLINCH RIVER
TO KNOXVILLE
TO KINGSTON
TO LENOIR CITY
LEGEND
A – OPERATORS VILLAGE
B – CONSTRUCTION CAMP
C – ELECTROMAGNETIC PLANT
D – SEMIWORKS
E – GASEOUS DIFFUSION PLANT
0 1 2 3
MILES

MAP 4



CEMESTO HOUSES ON BLACK OAK RIDGE, *Clinton Engineer Works, Tennessee.*

house have a fireplace and a porch. Since time was short, manpower scarce, and many materials were critical, a family unit developed by the John B. Pierce Foundation seemed just right for the purpose. Featuring prefabricated "cemesto" panels, consisting of fiber board with asbestos-cement bonded to both sides, and slotted wooden posts, the unit made use of available materials and permitted assembly-line construction. Cemesto, combined with brick instead of wood, also figured in Merrill's plans for attractive, modern, low cost schools. While Stone & Webster pushed work in the town center and provided utilities for a population of 12,000, O'Driscoll & Grove of New York City built the first thousand houses on the ridge.[75]

Over behind the hills, in Bear Creek Valley, men strained to meet a sterner challenge: construction of Y–12, the huge electromagnetic plant. Scientifically, industrially, in every way, the

[75] (1) Ernest A. Wende, "Building a City from Scratch," *ENR*, December 13, 1945, pp. 149–50. (2) George O. Robinson, *The Oak Ridge Story* (Kingsport, Tenn.: Southern Publishers, 1950), pp. 47–51. (3) Groueff, *Manhattan Project*, pp. 162–66. (4) Marshall Interv, 19 Apr 68. (5) Williams Interv, 26 Sep 68.

plant represented a daring leap from laboratory scale and methods. Research was still in progress and equipment only partially designed when excavation began on 18 February 1943. Bundles of drawings received from Boston gave project manager Williams a rough idea of what he was to build: three, and possibly four, huge concrete and masonry structures to house the separation process; two chemistry buildings for preparing feed material and recovering the final product; a development plant, complete with experimental calutrons; plus utilities, roads, spur tracks, storehouses, shops, a foundry, and numerous other supporting facilities. The plans showed the general layout, size, and profile of the process machinery: fantastic "race tracks"—enormous ovals formed by many jumbo magnets; vacuum systems larger and more powerful than any heretofore dreamed of; and rube goldberg phantasmagorias of pipes and valves. But many particulars were lacking, among them designs for vacuum pumps, ion sources, and receptacles. And troublesome questions were unanswered; for instance, would two stages of separation, Alpha and Beta, be required or would Alpha alone do the job. Although details were fuzzy, Williams pushed construction with all possible speed, for if the project was big and complicated, it was, above all, urgent. Groves wanted one racetrack in operation by July.[76]

Far smaller than Y–12 but scarcely less critical was the semiworks or X–10 plant in Bethel Valley. Explaining his decision to undertake this project, Groves dwelt upon the desperate need for uranium that had undergone irradiation in a pile and thus contained plutonium; until this need was met, planning for the chemical separation plants at Hanford would be handicapped. X–10 would meet other needs as well; although not a true pilot, it would nevertheless provide a practical demonstration of the basic production process and offer a means for training operating personnel. As blueprints emerged from DuPont's Wilmington drafting rooms, the construction task assumed fixed dimensions. Comprising the heart of the semiworks would be an experimental air-cooled pile, underwater storage, an underground canal, and a series of cells for chemical separation—all shielded by thick concrete walls and all operated by remote control. Other major structures would include laboratories, shops, a training school, and subterranean tanks for radioactive waste. When construction forces started work in February 1943, two veteran field engineers were on the scene: DuPont project manager Wilson and Captain Grafton, recently transferred to Clinton from Chicago. Both had tackled tall jobs before, but never a job like this. Key scientific decisions were still up in the air and the deadline for completion was "next fall."[77]

The buildup at Clinton was remarkably swift. Suddenly, in the early months of 1943, the hidden project in Tennessee became a loadstone for war-scarce manpower and supplies. Talks with regional labor leaders paved the way for a vigorous recruiting drive. Assists from the

[76] Hewlett and Anderson, *The New World*, pp. 142–52.

[77] (1) Groves, *Now It Can Be Told*, pp. 78–79. (2) Hewlett and Anderson, *The New World*, pp. 194–97. (3) Ltr, Grafton to authors, 11 Nov 68.

War Manpower Commission, the U.S. Employment Service, and Colonel Barker's staff in OCE helped to assure success. Construction forces mushroomed despite the need for at least a limited security check on every applicant. The largest payroll, Stone & Webster's, jumped from 1,000 men in January to 7,300 in April. Intensive courses in welding and other trades eased shortages of skilled workers; and women draftsmen, rodmen, and chauffeurs gave the job a boost. While early recruitment was largely local, procurement was country-wide. From towns and cities in nearly every state, shipments converged on the whistle-stops of Elza and Oliver Springs. Freight cars jammed sidings for miles around and traffic clogged highways, as thousands of tons of materials and hundreds of machines and vehicles flowed into the area. Materials bought by the contractors, purchases made centrally by Colonel Sherrill, and surplus transferred by Captain Rentenbach from other Corps jobs nearly swamped the project. Receiving and checking and distribution were major operations. Labor gangs, some composed entirely of Negro women, worked around-the-clock unloading, and carpenters put up the first of fifty big warehouses.[78]

Spring found construction moving forward amid rain and mud. Subcontractors' nameboards dotted the site—Clinton Home Builders of Charlotte, Foster & Creighton Company of Nashville, Harrison Construction Company of Pittsburgh, Transit-Mix Concrete Corporation of New York City, and D. W. Winckelman of Syracuse. Long lines of automobiles passed through the heavily guarded gates each morning and evening. Working conditions were still primitive (tank wagons hauled drinking water from the town of Clinton seven miles away and circus tents housed canteens), yet evidence of progress was all around. The main line connection with the Louisville & Nashville, completed and in use; a rambling frame laboratory, occupied by Met Lab scientists; deep excavations in the plutonium separation area; foundations under way for two Y-12 process buildings; a pump house and a filter plant rising near the Clinch River—these were among the highpoints. To Colonel Marshall, a frequent visitor, the job appeared to be going fairly well. To Groves, who showed up every other week or so for a predawn parley and a rigid inspection, the pace seemed fast but not nearly fast enough; he maintained a steady drumbeat for greater speed.

Meanwhile, two thousand miles northwest of Clinton, near the big bend of the Columbia River, a second production complex—the Hanford Engineer Works—was coming under development. Groves' mid-January decision to acquire 670 square miles of semiarid land in south central Washington had prompted brisk activity: subsurface explorations by the Seattle District; a power survey by Giroux and a site reconnaissance by Zach; establishment by the Portland District of a real estate office at Prosser; large-scale purchases of materials and equipment by Colonel Sherrill and DuPont; calls from the Chief's office to the field for surplus steel, relay rail, electric wire, trucks, tractors, loco-

[78] (1) Williams Interv, 26 Sep 68. (2) Notes of Conf, Groves, Lawrence, Lotz, *et al.*, 24 Apr 43. MED Files, 337 LC. (3) Thornburg, *et al.*, "Men and Materials," *ENR*, December 13, 1945, pp. 126–28. (4) 411.5, 412.42, 413.8, and 453.3 (CEW).

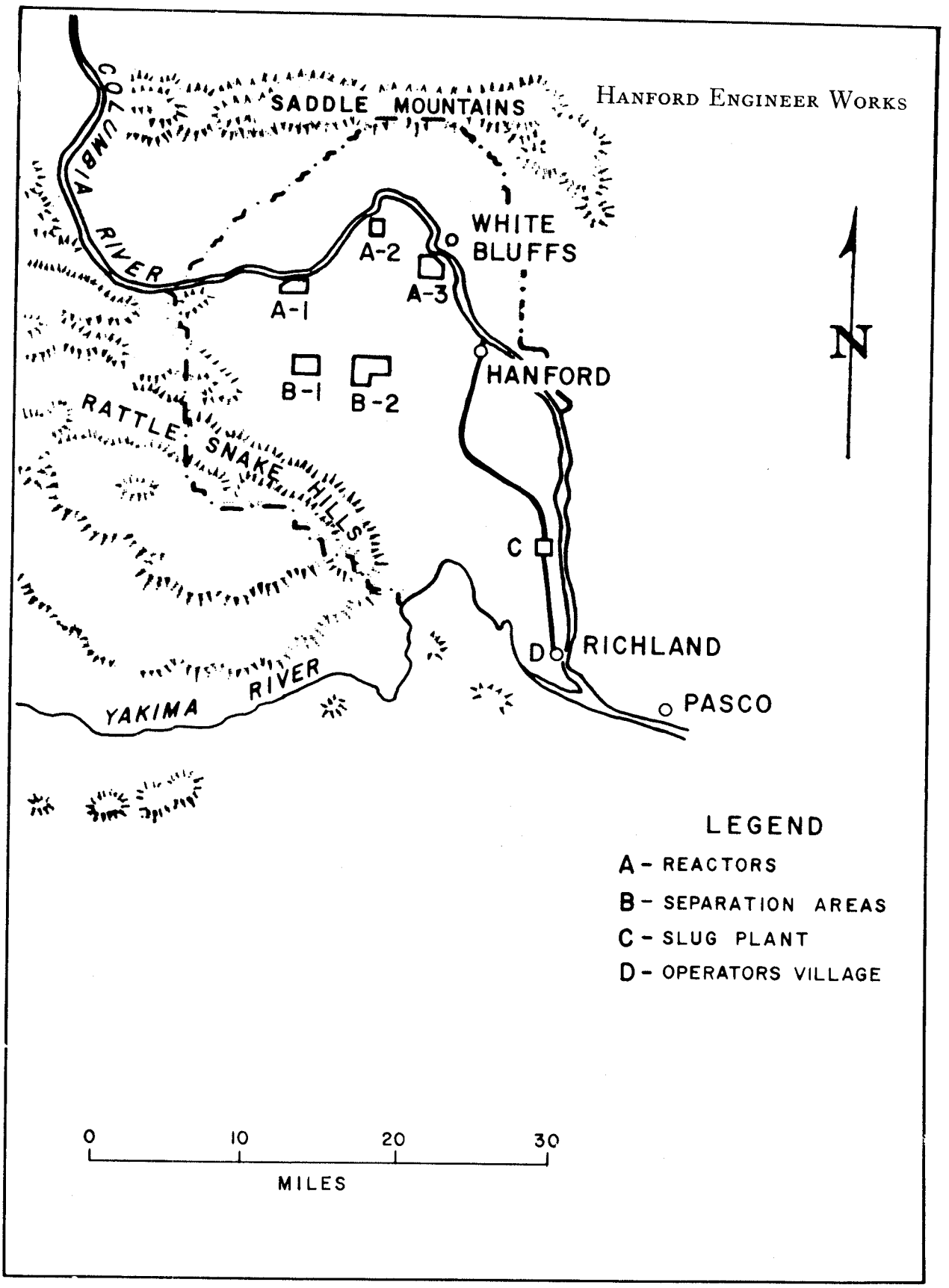
motives, and myriad other items; and countless meetings in Washington, Wilmington, Chicago, and New York. By mid-March preliminaries were well advanced. Temporary offices at the Gray Building in Pasco buzzed with new arrivals: Colonel Matthias, who had volunteered for the post of area engineer; Lt. Col. Harry R. Kadlec, his highly regarded deputy; Gilbert P. Church, DuPont's project manager; Leslie S. Grogan, his field superintendent; and large supporting staffs. A petition in condemnation had sailed through the Federal Court at Spokane; a hook-up with the Bonneville-Coulee power grid was in the works; arrangements were firming up to restrict flights over the area; the architect-engineer for the operators village, G. A. Pehrson of Spokane, was ready to start work; and the general layout for the entire project was falling into place.[79]

Late in March Groves and O'Brien spent two days at the job, going over the ground and settling details. With Church and Matthias, they covered many miles; northwest from Pasco to Richland, a hamlet nestled in the Y formed by the conflux of the Yakima and the Columbia; then on over parched dirt roads, through wide stretches of sand and sagebrush, to the villages of White Bluffs and Hanford. From a butte opposite White Bluffs, above the blue Columbia, they commanded a good view of the roughly circular site: the steep-faced Saddle Mountains on the northern rim; the narrow zone of irrigated orchards and croplands along the winding river; and the gray expanse of undulating tableland bounded on the south by the Rattlesnake Hills. At evening sessions in Pasco, Groves reviewed the layout: three huge reactors spaced miles apart on the right bank of the river; two chemical separation areas some distance to the south; a big construction camp at Hanford; a plant for making uranium slugs and testing pile materials midway on the Richland-Hanford road; and a town for operating personnel at Richland. (*Map 5*) Meantime, at after-dinner meetings with the real estate group at Prosser, O'Brien went over acquisition plans. At Groves' suggestion, he kept two secondary requirements in mind, minimum publicity for the project and maximum co-operation with the President's "Food for Victory" program. With construction planning barely begun, there was no need to bear down. Partly to soften owners' protests and partly to salvage growing crops, O'Brien told his men to rely mainly on negotiation, hold off eviction notices as long as possible, and let farmers and orchardmen bring in their harvests. Later, when bumper crops raised asking prices and sellers' resistance stiffened, Groves regretted this leniency, for the Hanford acquisition proved to be long and litigious.[80]

As the magnitude of the construction job became apparent, pressure began to mount. Planned on the same basic principles as the Clinton semiworks, the Hanford project was nonetheless formidably dissimilar; the 112-acre site in

[79] (1) Matthias Diary, Feb–Mar 43. (2) 410, 411.5, 412.42, 451.2, and 453.7 (HEW). (3) Ltr, Matthias to OCE, 8 Mar 43. 413.8 (MDO). (4) Ltr, Matthias to authors, 28 Apr 64. (5) TWX, Marshall to Reybold, 5 Mar 43. 210.3 (MDO).

[80] (1) Matthias Diary, 24–25 Mar 43. (2) Memo, O'Brien for Amberg, n.d. EHD Files, Leasing. (3) Groves, *Now It Can Be Told*, pp. 76–77. (4) Jones, MANHATTAN, ch. VIII, pp. 44–88.


HANFORD ENGINEER WORKS
COLUMBIA RIVER
SADDLE MOUNTAINS
WHITE BLUFFS
A-1
A-2
A-3
B-1
B-2
HANFORD
RATTLESNAKE HILLS
C
D
RICHLAND
PASCO
YAKIMA RIVER
N
LEGEND
A - REACTORS
B - SEPARATION AREAS
C - SLUG PLANT
D - OPERATORS VILLAGE
0
10
20
30
MILES

MAP 5

Bethel Valley was tiny compared with the vast sweep of prairie north of Pasco, and the Clinton pile's expected power output of 1,000 kilowatts shrank to insignificance beside the 250,000 kilowatts of each Hanford pile. There were other marked differences also. Unlike the Clinton midget, the giant reactors at Hanford would be water-cooled, a circumstance that raised such varied problems as rust prevention and streamlife preservation. The remoteness of the Hanford tract was another exceptional feature; since the nearest city of any size, Yakima, was 40 miles away, recruiting, transporting, housing, and feeding the workforce would take a lot of doing and so would keeping up morale. Massive industrial structures, heavily shielded to confine radiation and designed for operation by remote control, a permanent town for 17,000, a construction camp for 40,000, plus administration buildings, depots, shops, laboratories, test facilities, pumping stations, filtration plants, and hundreds of miles of roads, railroads, and transmission lines—the scope of the undertaking was impressive. The best way to meet the challenge was to tackle it head-on. Bringing machinery and materials from other Corps projects, recruiting labor throughout the northwest, opening gravel pits and obtaining concrete batch plants, establishing bus connections with nearby towns, erecting barracks and tents at Hanford, inaugurating food service, letting contracts for Richland Village, studying how to safeguard the Columbia River salmon, and pushing "hard and fast" on roads and railroads—all these activities proceeded during the spring of 1943. By May, 1,300 men were at work. With luck, the main task of plant construction would start in the summer.[81]

Although dwarfed by Clinton and Hanford, other industrial construction jobs were pressing and important. On Colonel Marshall's crowded itinerary were Milwaukee, Wisconsin, where the Allis-Chalmers Company was expanding to manufacture pumps; Niagara Falls, New York, where the Electro Metallurgical Company was erecting facilities to cast uranium ingots; and spots in Alabama, Colorado, Indiana, Iowa, Michigan, New Jersey, and West Virginia. Of the various auxiliary plants, those for heavy water were perhaps most noteworthy. The possibility of failure with graphite piles dictated Groves' decision in November 1942 to augment supplies of heavy water. At his request, DuPont engineers took the matter in hand. After weighing possible production methods, including the electrolytic process used at Trail, they backed distillation as the surest and quickest, though not the most economical. Soon plans were afoot for distillation units at three Ordnance works having excess steam capacity, Morgantown, Alabama, and Wabash River, plus an electrolytic finishing plant at Morgantown. A "horseback guess" put the cost at about $28 million. Started by DuPont in January and February 1943, the projects raced to meet close deadlines—partial operation by mid-summer and final completion by the end of the year.[82] With many

[81] (1) Franklin T. Matthias, "Building the Hanford Plutonium Plant," *ENR*, December 13, 1945, pp. 118–24. (2) Matthias Diary, Apr–May 43.

[82] (1) Hewlett and Anderson, *The New World*, pp. 292–94 and 104. (2) MD Hist, Book III. (3) Ltr, DuPont to Groves, 17 Mar 43, and Incl. MED Files, 600.12 (P-9). (4) Memo, Nichols for Groves, 17 May 43, and related docs. MED Files, 161. (5) Interv with Harry S. Traynor, 7 Nov 68.

such undertakings at scattered locations, the MED building effort was a miniature war construction program in itself.

Undergirding endeavors in the field was powerful support from contractors' home offices. At Boston, Stone & Webster had a special force of 800 employees, occupying 13 floors in 4 heavily guarded buildings, at work on the atomic program. Headed by the firm's chief mechanical engineer, dynamic, genial August C. Klein, this group discharged heavy duties: translating scientific data into construction plans and blueprints; procuring process equipment from Allis-Chalmers, General Electric, Westinghouse, and other manufacturers; expediting orders of basic raw materials, including uranium; and overseeing operations at Clinton and Trail. At Wilmington, DuPont had a comparable organization under the direction of chief engineer Everett G. Ackart and his hard-driving principal assistant, Granville M. Read. Early in the game, a 400-man design team toiled over information submitted by the Met Lab; in time, the pile project soaked up 90 percent of the company's engineering and construction talent. From the Woolworth Building in downtown Manhattan, a newly created Kellogg subsidiary, the Kellex Corporation, pioneered development of the gaseous diffusion process. The staff, which grew eventually to about 3,000, included many luminaries of the engineering profession, but none more brilliant than the president, Percival C. Keith.[83] With researchers at Columbia and associated universities, Keith and his group had baffling obstacles to overcome. Bracketing Kellex and the other contractors, Nichols related, "In every case, they really worked their hearts out to get the thing done."[84]

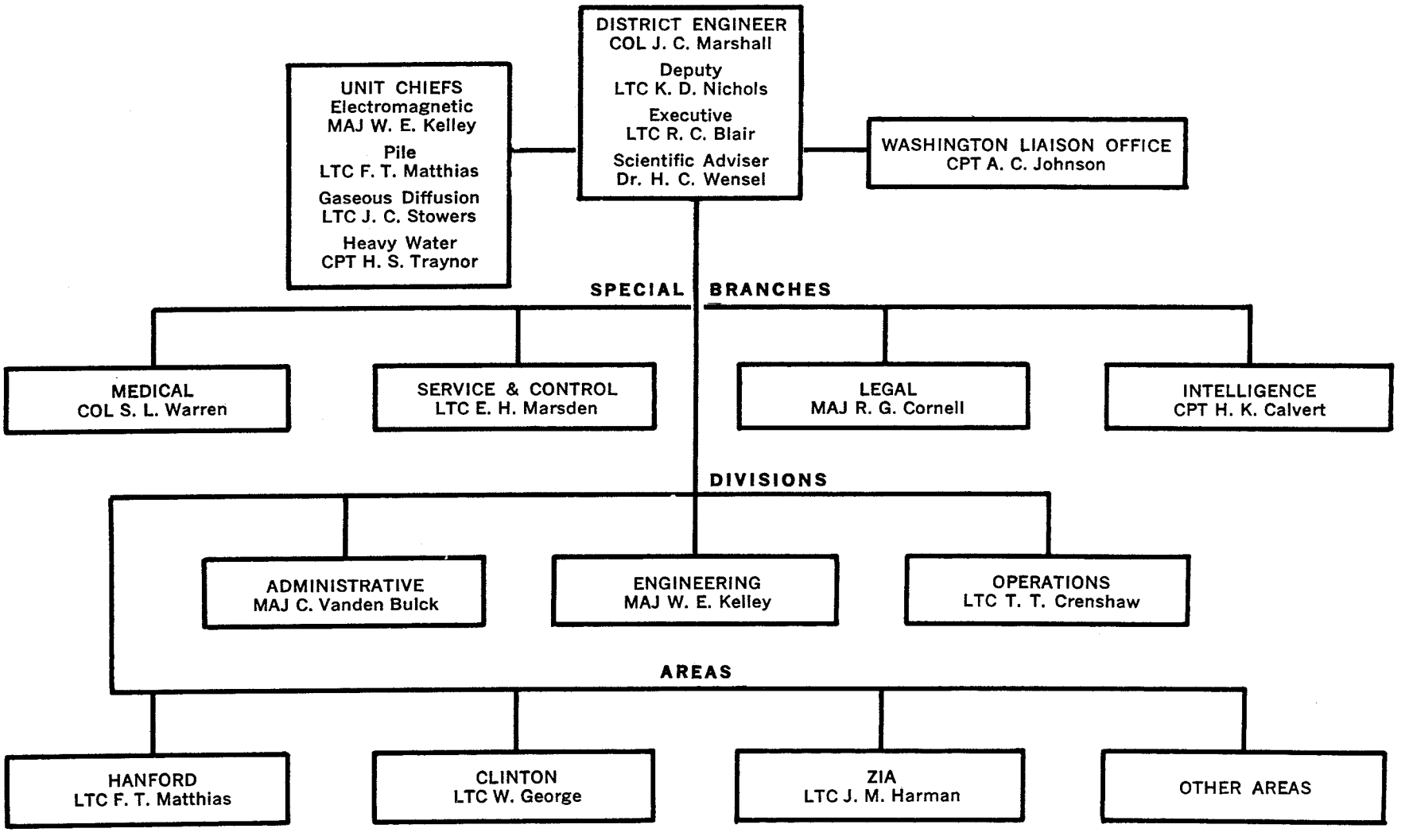
Tying all these vital cords together was the Manhattan District centered in New York. Grown too large for its Broadway headquarters, Colonel Marshall's staff had taken over floor after floor of a garment industry building at 261 Fifth Avenue. Aiming for "the same kind of District that we had at Syracuse," Marshall relied on the same sort of personnel and the same type of setup. The majority of his officers were Corps employees in uniform and many of his civilian aides wore Corps service pins in their lapels. But for a few exceptional features—a scientific adviser (Dr. Henry T. Wensel), a chief medical officer (Col. Stafford L. Warren), and four unit chiefs or process co-ordinators (Kelley for electromagnetic, Matthias for the plutonium piles, Lt. Col. James C. Stowers for gaseous diffusion, and Capt. Harry S. Traynor for heavy water)—the MED organization chart could have served most Engineer districts. (*Chart 27*) "We had a good organization," said Nichols, "and a group of people that could work together." The only rub was Groves. Dealing with him was "an interesting and difficult problem," according to Nichols: "There was no question as to his ability, but his methods of working were to violate all channels." Marshall, who outranked Groves on the permanent promotion list, did not take kindly to this mode of operation. "Who is the District Engineer?" he demanded. "You

[83] (1) *A Report to the People: Stone & Webster Engineering Corporation in World War II* (Boston: Stone & Webster, 1946), p. 13. Cited hereinafter as *A Report to the People.* (2) Groueff, *Manhattan Project*, pp. 167–68, 139, 131, and 105–06.

[84] Nichols Interv, 18 Feb 64.

Chart 27—Organization of Manhattan Engineer District, April 1943

(Simplified)



Source: Orgn. Chart, MED, 1 Apr 43. EHD Files.

are," Groves replied. "Who gives the orders?" "You do." Nevertheless, as time went on, the general exerted more and more authority. At one point, Marshall told him, "There is no need for both of us here; I want out." Groves demurred, but finally agreed: "O.K., at the first opportunity." Absorbed in his work, Marshall soon forgot the conversation; and, apparently, so did Groves. The two men pegged along, disagreeing occasionally, but never reaching an impasse. Too big to harbor grudges, they pushed toward their common goal.[85]

Both kept an anxious eye on Clinton, a healthy project on the whole, but not immune to trouble. By May 1943 the job was bounding ahead. The atmosphere was one of challenge and excitement, and the spirit was enthusiastic. The construction camp was filling up, as recruiting centers throughout the South funneled workers to the site. A ten-hour shift and a partial second shift kept equipment running from dawn to dusk, and unloading crews grappled with hundreds of incoming freight cars. Three thousand houses were under construction on Black Oak Ridge, and water and sewer lines were advancing at the rate of one mile per day. In the Y–12 area, dozens of structures, among them a recently authorized Beta process building, were going up, and the development plant, started in mid-April, was already roofed. The plutonium semiworks was right on schedule. Good progress notwithstanding, the job produced its share of headaches. Two were political: a strained relationship with the Governor of Tennessee and an impending congressional probe into land acquisition. Another was administrative: a personality clash between George and Williams, in part smoothed over after Blair took command of Clinton on 15 May and George became his construction officer.[86] But these problems, however vexing, were relatively minor. The really big ones flowed from the complexities of the engineering task.

Foundations for the Y–12 process buildings proved to be a rugged undertaking. From the beginning, some difficulty seemed inevitable. "Everybody knew the place was faulted," Williams pointed out; and because of the many heavy magnets, load concentrations would be quite high and permissible settlement, practically zero. With due precaution, Stone & Webster mobilized a crack team of foundation engineers, captained by Lynnwood Kerr, one of the best men in the business.[87] Early in 1943 Kerr sent William F. Swiger, a young Harvard-trained soils technologist, down from Boston to take core-borings and dig test pits. On the north side of Bear Creek Valley, Swiger found underground formations of Conosauga shale, an excellent support for heavy structures. On the south side, where the main process buildings were to go, he came upon less favorable conditions: uptilted beds of deeply weathered limestone. After rejecting several alternatives, Kerr adopted a procedure which

[85] (1) Marshall Interv, 19 Apr 68. (2) Nichols Interv, 18 Feb 64.

[86] (1) Interv with Edward J. Bloch, 13 Nov 68. (2) G. E. Crosby and P. B. Streander, "Water Supply and Sewage Works for the Atomic Bomb City," *ENR*, December 13, 1945, p. 154. (3) Traynor Interv, 7 Nov 68. (4) Williams Interv, 26 Sep 68. (5) Ltr, Blair to authors, 24 Jan 1969. (6) 601.1 (CEW) II. (7) Ltr, Marshall to Blair, 5 Jul 43. 161 (CEW).

[87] Williams Interv, 26 Sep 68.

worked nicely for the first two Alpha buildings: stripping the surface, grouting seams and joints, and founding footings on this "dental work." When excavating crews removed the overburden at the site of Alpha III, he faced crueler obstacles: irregular boulders up to 30 feet in diameter, lodged closely together and imbedded in soft clay. "Here," he wrote, "was real trouble, so serious that time and labor expended in attempting to excavate to suitable foundations only made conditions appear more hopeless." Eventually, he opted for an unorthodox method, a military engineer's expedient proposed by Groves. Leaving the rock where it was, he flushed out the muck with firehoses and then poured a heavy concrete mat, two to three feet deep in some spots, eight feet in others, which amalgamated the whole mass into one firm solid base. Conventional engineering or not, the trick succeeded. The job was well and swiftly done.[88]

When earthmovers started work in Happy Valley on June 2d, the atomic project passed another milestone. Picked by the Lewis Committee as the method most likely to succeed, gaseous diffusion—K–25 in code—was also the most disheartening. Based on Graham's Law, the process was beautifully simple in theory—when uranium hexafluoride gas was pumped against porous membranes, the lighter U–235 molecules would tend to pass through more easily than the heavier U–238—but making it work industrially was a herculean labor. Thousands of separation stages, millions of kilowatts of electricity, unique metallic barriers or membranes with countless submicroscopic holes, pumps and seals of revolutionary design, new coolants and lubricants, corrosion-proof materials, vacuum tightness, surgical cleanliness, and watchmakers' tolerances were items in the engineer conspectus. Moreover, the Columbia scientists, at odds with one another, inspired Groves with far less confidence than the ebullient Lawrence team or the coolly competent Met Lab group. Bright spots in the picture were "Dobie" Keith and his "can-do" associates, whose initial progress was reassuring, and the Union Carbide engineers, who were moving into operational planning. As development of component parts went forward (soon the barrier remained the chief unsolved riddle) and as construction drawings multiplied (the total would eventually reach 12,000), Groves made a bold commitment. In mid-May Marshall signed a letter contract with the J. A. Jones Construction Company for the largest steam-electric power plant ever built. Within a fortnight, Jones' men were on the scene.

High-geared and high-priced, the power plant project exemplified the don't-spare-the-horses spirit of MED. Scheduled for completion in 10 months, the $185-million generating station was an added safeguard, another hedge against misfortune. The decision to build it rested on the scientists' belief, later proved unfounded, that a momentary outage would shut down K–25 production for many weeks and also on the reasoning that since TVA current, coming by wire, was subject to interruption by storms and sabotage, locally generated current was a necessity. A difficult undertaking at best, construction of the plant

[88] Lynnwood Kerr and Paul Brown, "Process Buildings Over Faulted Rock," *ENR*, December 13, 1945, pp. 129–31. See also Ltr, William F. Swiger to authors, 18 Nov 68; and Groves Interv, 11 Feb 64.

was rendered more difficult by unfavorable site conditions and wartime shortages. By bringing in top-notch subcontractors, among them the A. S. Shulman Electric Company of Chicago and The Foundation Company of New York; by commandeering boilers and turbines intended for Commonwealth Edison's new Fiske Street Station in Chicago; and by vigorous expediting, MED leaders helped the cause along. Within a short time, the job was booming.[89] Assigned to Clinton in late July as K–25 construction officer, Maj. William P. Cornelius found the powerhouse "fairly well established."[90]

The same vim was evident at Hanford, which was fast taking on the atmosphere of a wild West frontier town. An intensive recruitment program, launched in the spring of 1943, had unexpectedly quick results. Barred from the industrial areas of Washington and Oregon by the War Manpower Commission, DuPont agents fanned out through the Great Plains, enlisting hundreds of workers each week. Coping with the influx of new employees—a total of nearly 10,000 in May, June, and July—kept Church and Matthias on the go. Providing room and board was an especially arduous task, since local custom demanded that men bunk two to a room and have table service at meals. Maintaining order and arousing enthusiasm were no easy matters. Many of the workers were rough and tough and far from the restraining influences of family and friends. Brawling, drunkenness, and thievery in the barracks called for dexterous handling. Moreover, an unbalanced workforce—the ratio of skilled to common labor was far too high—hampered operations. But despite drawbacks, construction moved ahead. Experienced subcontractors reinforced DuPont: among them, Guy F. Atkinson of San Francisco, Twaits-Morrison-Knudsen of Los Angeles, and Hankee-James-Zahniser & Warren of St. Paul. Additions to project staffs strengthened management and a stream of visitors from Chicago, Wilmington, and Washington gave advice and support. By mid-summer preparations were virtually complete and shovels were scooping out foundations for the piles.[91]

Abruptly, on 20 July 1943, the Manhattan District underwent a change in leadership. Colonel Marshall was in the Governor's office at Nashville, when a rush call came through to him from Groves. "Congratulations," said the general and blurted out the news: Marshall was getting a brigadier's star and going to command Camp Sutton; Nichols was taking over as district engineer. Shocked and indignant, Marshall concluded, despite Groves' denials, that he was being fired. General Reybold soon put the matter to him in a different light: noting that Marshall was overdue for a well-deserved promotion and that his current post did not call for one, the Chief had asked Groves to release him.[92] In a touching message, Marshall bade farewell to MED:

> My change in assignment has come about through no desire for such a change on my part. . . . I feel that we have the finest

[89] John D. Watson, "Building a Power Plant in 10 Months," *ENR*, December 13, 1945, pp. 141–44.

[90] Interv with Col William P. Cornelius, 15 Nov 68.

[91] (1) Matthias Diary, May–Sep 43. (2) Groves Interv, 11 Feb 64. (3) Ltr, DuPont Explosives Dept to Nichols, 4 May 43. MED Files. 161 (DuPont).

[92] (1) Marshall, Office Diary, 20 July 43. EHD Files. (2) Marshall Interv, 19 Apr 68. (3) Groves, *Now It Can Be Told*, p. 29.

organization in the Corps of Engineers, one that the Chief of Engineers and others in authority familiar with our work know is doing a fine job . . . . The district has a long task ahead of it, but I know that a continuation of the wholehearted efforts being put forth by all of you . . . will produce the results expected by the War Department.

Adios.[93]

His departure gave Groves a freer hand. Almost immediately, district headquarters moved from New York to Tennessee, a switch the general had long urged on Marshall. Although most stayed on, some members of the old guard left for overseas and men of Groves' own stamp came in to replace them. Going out of channels became more or less routine. Informal and unmilitary, the system worked successfully because the officers involved were more intent on getting the job done than on asserting prerogatives. In particular, Nichols' forbearance won the admiration of associates. To many of them the smooth, level-headed, thoroughly competent young officer was the hero of the piece.

In both the widely separated areas which were the principal scene of its mysterious construction activities, the Manhattan District faced similar basic problems, differing in detail, but alike in the complications caused by wartime scarcities. Mere statistics spoke volumes; combined requirements for Clinton and Hanford included 360,000,000 board feet of lumber, 1,200,000 cubic yards of concrete, more than 75,000 tons of structural steel, and 22,500 pieces of equipment. Contractors did most of the purchasing; Stone & Webster paid out a total of $260,000,000 to vendors and DuPont's Hanford field office alone placed 42,000 orders. Even so, many essentials came courtesy of the Corps: the Central Procuring Agency bought 80 percent of the lumber and the bulk of the rail and reinforcing steel; districts and divisions unearthed divers hard-to-get items; and most construction machinery was recaptured surplus. While hundreds of expediters helped speed deliveries, the prime troubleshooter was Captain Johnson of the Washington Liaison Office. Manhattan's assigned priority, AA–3 until March 1943 and AA–2x thereafter, though effective ordinarily, often proved too low. At least 50 calls for help reached Johnson every week. With the super triple-A rating, always in reserve, he could, and repeatedly did, edge out competing war programs. "We were notorious for robbing people," said Nichols. Victims, unable to fathom the atomic secret, complained bitterly. Soothing "gripes on interference caused by our work" became one of Johnson's routine duties, and, occasionally, Groves, Patterson, or Stimson had to damp down discontent.[94] Strained and stringent though it was, the procurement effort succeeded. One way or another, the Army and its contractors kept the crucial projects well supplied.

Manpower, not matériel, was the agonizing headache. At the peak of construction, Hanford employed 45,000 workers; Clinton, 47,000. With millions

[93] Ltr, Marshall to All Employees, 23 Jul 43. EHD Files.

[94] (1) Ltr, Johnson to Marshall, 16 Mar 43. MED Files. 201 (General). (2) Nichols Interv, 18 Feb 64. (3) WPB Files. 411.33 (Constr Projects–Mil). (4) MED Files. 400.1301 (Priority).

in the armed services and in defense plants, mustering these forces was no mean feat. Although contractors did most of the brush beating, Engineers also played an influential role. Colonel Barker's dedicated efforts earned Groves' encomium: "a key man to the success of the undertaking."[95] Full co-operation from war manpower authorities, all-out support from leaders of the building trades, timely wage boosts in critically short crafts, and diplomatic arbitration of disputes were among his contributions. Other loyal helpers were General Robins, who pressed the district engineers into service as recruiters, and Lt. Col. Edward A. Brown, Jr., of OCE, who assisted in forming elite Special Engineer Detachments, made up of technically educated GI's, to take over scientific chores for which civilians were unobtainable. Barely less troublesome than problems of recruitment were problems of stability and morale. Turnover was abnormally high at both Clinton and Hanford; many weeks new hires did little more than match dropouts. Absenteeism was flagrant and discontent was widespread. Gripes commonly heard at construction camps could not explain the situation; but some observers felt that secrecy could. In the dark as to end products, workers tended to view the plants as colossal boondoggles. A desire for war work was a frequent reason for quitting. Nichols' labor relations man, Lt. Col. Curtis A. Nelson, applied every known remedy—appeals from Reybold and Robins, patriotic posters and Army displays, recreation and entertainment programs, complaint periods, exit interviews, and more. These measures helped subdue unrest but could not dispel it.[96]

Progress surveys in the fall of 1943 showed much good work accomplished but much more still to do. At Hanford the first pile building, a massive, windowless cube, was rising from the desert amid a jumble of related structures; parts of the fabrication and testing center were already in use; two large excavations, abandoned temporarily for want of manpower, told where the separation plants would stand; the sprawling construction camp, a patchwork of barracks, tents, and trailers, could accommodate 13,000 persons; and Richland, the white collar village, was home to several hundred families. At Clinton, where Crenshaw had succeeded Blair, a great deal of construction was in place. The community of Oak Ridge, named by Colonel Marshall, was a rapidly growing city, managed by the newly formed Roane-Anderson Company. Labor camps flourished at three locations, and development of utilities, roads, and railroads was proceeding apace. The semiworks was nearing completion and would produce its first plutonium, a tiny amount but enough to experiment with, before the end of the year. The Y–12 project was going like a house afire. Many minor structures were in service and the first Alpha racetrack was undergoing trial runs. Far behind the other processes, K–25 was the longshot in the race for bomb stuff; not until September did

[95] Groves Interv, 11 Feb 64.

[96] (1) Ltr, Robins to Div and Dist Engrs, 26 Oct 43. 600.1 (MDO) (Labor) Part 1. (2) 220.3 (MDO). (3) 320.22 (MDO). (4) 600.1 (CEW) (Labor). (5) 600.1 (HEW) (Labor). (6) Message, Robins to Workers at CEW, 25 Nov 43. 330.11 (CEW). (7) Message, Reybold to Men and Women of CEW, 10 Feb 44. 201.21 (CEW).

excavation for the main gaseous diffusion plant get under way. Two decisions around that time eased the pressure on K–25 and tightened the squeeze on Y–12. Encouraged by recent improvements in Lawrence's method and knowing that the final, upper stage of K–25 would require tremendous engineering efforts, Groves resolved, first, to use diffusion to carry separation only part way and, second, to double the size of the electromagnetic plant.[97] Asked afterwards how he reacted to this news, Cortlandt Williams pointed to a small bronze figure of Sisyphus at his incessant labor.

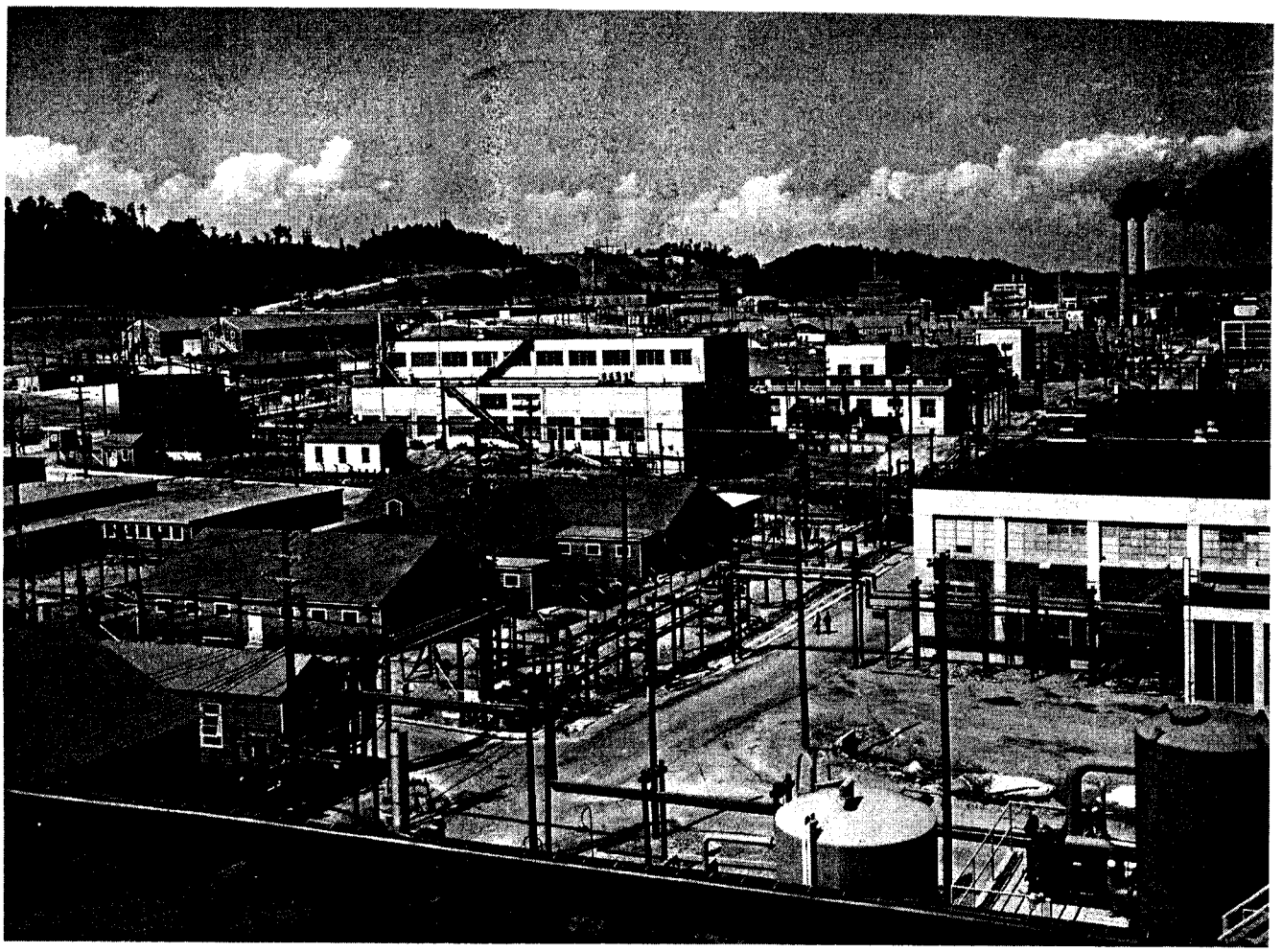
Scientifically the least elegant of all the processes and industrially the least efficient, Y–12 put constructors through a cruel ordeal. Embracing more than 160 separate buildings and a still crude technology, the plant construction job, in Williams' phrase, was the "most complicated ever." The killing pace, the novel industrial equipment, and the ultra high standards of workmanship were harrowing enough, but variable plans were even worse. As researchers at Berkeley scored repeated breakthroughs, engineers at Clinton strove frantically to stabilize design. Because electromagnetic separation was a batch method, design could be frozen by units or groups of units, and Groves soon insisted on doing so despite Lawrence's rebuke: "That's the stupidest thing I've heard yet."[98] Contending that successive freezes made the difference between "chaos and ability to get the job done," unit chief Kelley explained: "Had Groves not stepped on the scientists' toes, they would have just run wild with little changes." As the first process building neared completion in September 1943, Stone & Webster fought a tough bout, unscrambling equipment delivered out of sequence and rushing installation. With masons still at work on the opposite end of the structure, cranemen hoisted the heavy magnets into place and specially trained mechanics began final assembly of the number one racetrack. When the power was turned on in mid-October, project leaders received a hard blow. During trial runs, the 14-ton vacuum tanks crept inches out of line and, more serious, the magnet coils showed a tendency to ground. Baffling at first, the mystery of the tanks cleared up when someone remembered Maxwell's Third Equation; obedient to the laws of physics, the oval racetrack was trying to pop out into a circle. Anchored securely, the tanks stayed put. The mystery of the coils proved harder to fathom. Not until 5 December, when Groves ordered a magnet broken open, was the cause apparent: Major Kelley reached in and scooped out rust and scale by the handful. Grumbling about inexcusable carelessness, his own as well as others', Groves ordered drastic action: tear down the racetrack and send the magnets back to the factory for cleaning and rebuilding; erect a pickling plant and pickle every piece of pipe; install filters and do whatever else was necessary to eliminate contaminants from the system.[99] The job was in critical straits, and these were dark days for the Y–12 team.

Brighter days were slow in coming,

[97] (1) Hewlett and Anderson, *The New World*, pp. 215–16, 219, and 159–61. (2) Matthias Diary, Sep–Nov 43. (3) Robinson, *Oak Ridge Story*, p. 50 ff.

[98] Williams Interv, 26 Sep 68.

[99] (1) Interv with Dr. Wilbur E. Kelley, 14 Oct 68. (2) Groves, *Now It Can Be Told*, pp. 103–06.



Y-12, ELECTROMAGNETIC PROCESS PLANT

as ill luck dogged the enterprise and morale sagged. Electrical failures, mechanical breakdowns, shortages of spare parts, and many minor hitches and delays hampered round-the-clock efforts to get the second racetrack running. Using a favorite technique, Groves tried to revitalize the project by injecting new blood. Lt. Col. John S. Hodgson, a prominent contractor in civil life, replaced George as construction officer, and Maj. Walter J. Williams, who had a brilliant record on big Ordnance plant jobs, took charge of the original Y–12 area. The recently appointed head of the Y–12 extension, Maj. Mark C. Fox, one of the best area engineers in the country, stayed on. Meantime, apparently to take the heat off, Stone & Webster hired Frank R. Creedon, who had left the Construction Division in late 1942 to join the synthetic rubber program, as resident manager at Clinton. Brusque and bearish, Creedon offended the suave company executives, and eventually matters reached a point where he or Cortlandt Williams had to go. Williams went. Rating Creedon's performance as "miraculous," Groves credited the hard-driving methods they both espoused.[100] Miracles worked by any

[100] Ltr, Groves to Creedon, 17 Feb 45. MED Files. 201.22 (Ltrs of Appreciation and Commendation).

means were welcome at Y–12, for fresh obstacles loomed at almost every turn. One was especially forbidding. By the spring of 1944 several racetracks were in operation, but much of their product remained inside trapped in tubes and piping or buried in the mess of dust and metal flakes that splattered vacuum tank walls. Concentrating on the physics of separation, Lawrence had given too little attention to the chemistry of recovery. Dismantling the calutrons every week or two and scouring or scraping their parts upped the yield somewhat but not greatly. Assaults on the problem were nightmares of frustration, of testing one design and then another, installing pipe by the mile and then ripping it out again. Weeks went into months and still there was no answer.[101] Twinkling over his understatement, Groves reminisced, "It wasn't easy to bring the magnet around."[102]

Bringing around gaseous diffusion was no cinch, either. The main K–25 process building, a four-story U-shaped affair measuring more than one mile from end to end, was the largest in the whole Manhattan Project. Small by comparison, but a major undertaking in itself, was the so-called "conditioning" plant which would thoroughly clean all parts and preassemble process units. With the great steam-electric powerhouse, laboratories, shops, labor camps, and other appurtenances, K–25 covered nearly eight square miles. Already at work on roads, railroads, and utilities, J. A. Jones began the main separation plant in September 1943, about the same time that Ford, Bacon & Davis of New York broke ground in the conditioning area. Both firms placed ace men in charge: company executive Edwin L. Jones headed the Jones setup; and Charles C. Whittlesey, who had just completed a $60,000,000 synthetic rubber plant at Charleston, West Virginia, was project manager for Ford, Bacon & Davis. The job demanded all their expertise, for it raised many perplexing problems that "called for excursion far into the unknown."[103] The contractors adopted striking innovations, for instance, streamlined methods of surveying, dropped-in caissons for the powerhouse substructure, compacted fill foundations for the separation plant, and temporary partitions and movable electric substations to give the conditioning plant built-in flexibility. All the same, the project was a grind. "Clean as a surgeon's forceps" and "vacuum tight as a thermos bottle" were phrases Jones and Whittlesey would not soon forget. Devising adequate cleanliness controls, evolving special welding techniques, and developing leak detection tests were taxing assignments. And waits for plans from Kellex were nerve-wracking experiences. Patience, ingenuity, and hard work had results. By the spring of 1944, Cornelius could report steam in the powerhouse boilers, part of the conditioning plant in operation, and, on the main plant, foundations in, steel framework going up, and crews at work on the first separation stages. But barriers, the

[101] (1) Hewlett and Anderson, *The New World*, pp. 163–64 and 294–96. (2) Groueff, *Manhattan Project*, pp. 236–37. (3) Kelley Interv, 14 Oct 68. (4) Leslie R. Groves, "Development of the Atomic Bomb," *The Military Engineer*, June 1946, p. 237.

[102] Groves Interv, 11 Feb 64.

[103] Groves, "Development of the Atomic Bomb," *The Military Engineer*, June 1946, p. 237.

prime essential, were still lacking.[104] Aptly, Groves likened the job at this point to "building an automobile without a rear axle, inserting a broomstick between the rear wheels until we figured out how the axle should be made."[105]

Hanford, meantime, made haste slowly. Carefully conservative, DuPont engineers tried to reduce the risk of failure by using ample safety factors. Their attitude was "if fifty million extra dollars will help make us sure of success they should be spent."[106] Some hallmarks of their design were extremely close tolerances, almost perfect welds, alternate power systems, and duplicate water lines. Another, highly significant, was spare capacity built into each pile—500 tubes for uranium over and above the 1,500 specified by the Met Lab. Against protests from scientists who scorned empirical methods, Groves backed DuPont all the way, even to providing a $10,000,000 water purification plant, "just in case," that was never used. Superior craftsmanship was not good enough; perfection was the norm. Skilled mechanics had to undergo intensive training before their work could measure up. Persistent shortages of plumbers, millwrights, welders, and electricians hindered progress, and every feature added to the plant stretched the ranks thinner. Wise management offset certain handicaps, for example, specialists in central shops did much of the close precision work, prefabricating and prefitting materials for the process buildings; regular inspections and frequent servicing kept over-age equipment from breaking down; and on-site production plants assured supplies of concrete blocks and concrete pipe. Good year-round construction weather and ideal foundations of sand and gravel were unmixed blessings. By concerted action, DuPont and dozens of subcontractors pushed the project forward. By the second quarter of 1944, the first pile building was more or less complete and assembly of the pile itself was under way. The first separation building, a stark rectangular hulk of concrete and steel, was not far behind. If all went well, Hanford would start turning out plutonium in the fall. Nonetheless, grave misgivings tormented project chiefs. Recent reports from Los Alamos cast doubt on the value of the plant: making a plutonium bomb might prove impossible.[107]

In fact, the whole atomic venture might well end up as a mountainous fiasco. By mid-June, outlays totaled roughly $800,000,000, and the forthcoming military appropriation concealed an allocation of $600,000,000 more.[108] The industrial complexes at Clinton and Hanford staggered most observers; and so did the operators' "villages," for

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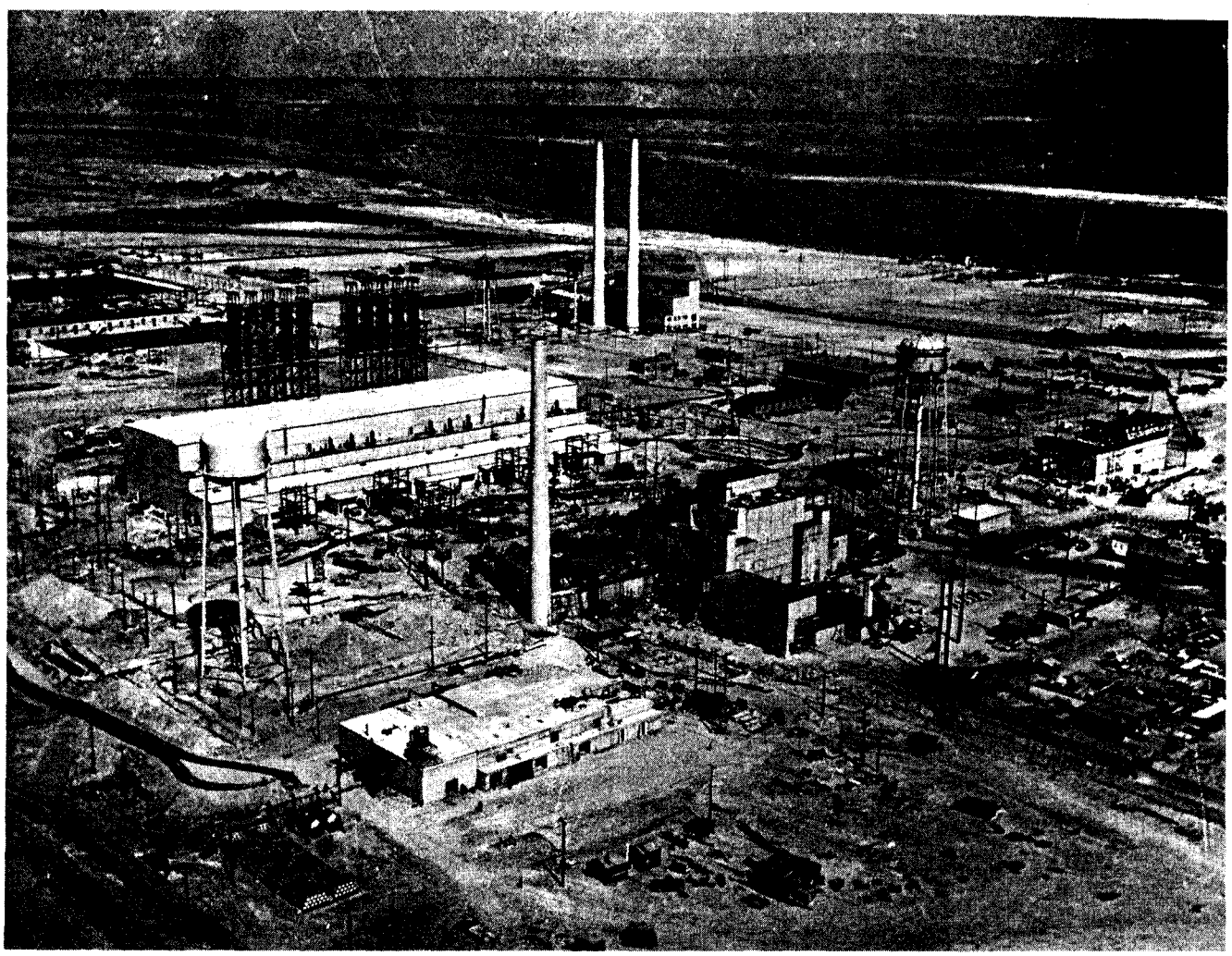
[104] (1) *ENR*, December 13, 1945: Howard J. Kornberg, "Surveying for Fast Construction," pp. 146–48; John D. Watson, "Building a Power Plant in 10 Months," pp. 141–44; John D. Watson and O. R. Bradley, "Compacted Fill Equals Natural Ground," pp. 144–46; and John F. Hogerton, "Largest of the Atom-Bomb Plants," pp. 134–37. (2) Min of Mtg, Jones, Cornelius, *et al.*, 28 Feb 44. MED Files, 001. (3) Hewlett and Anderson, *The New World*, pp. 130–41.

[105] Groves, "The Atom General," p. 101.

[106] Quoted in Compton, *Atomic Quest*, p. 194.

[107] (1) Nichols Interv, 18 Feb 64. (2) Hewlett and Anderson, *The New World*, pp. 217–18 and 220. (3) John F. Sembower, "On-the-Job Training Speeds Completion of Atomic Bomb Project by 45,000 Workers," *Construction Methods*, December 1945, pp. 104–106 and 146–56. (4) Matthias, "Building the Hanford Plutonium Plant," *ENR*, December 13, 1945, pp. 118–24.

[108] Hewlett and Anderson, *The New World*, pp. 289–90.

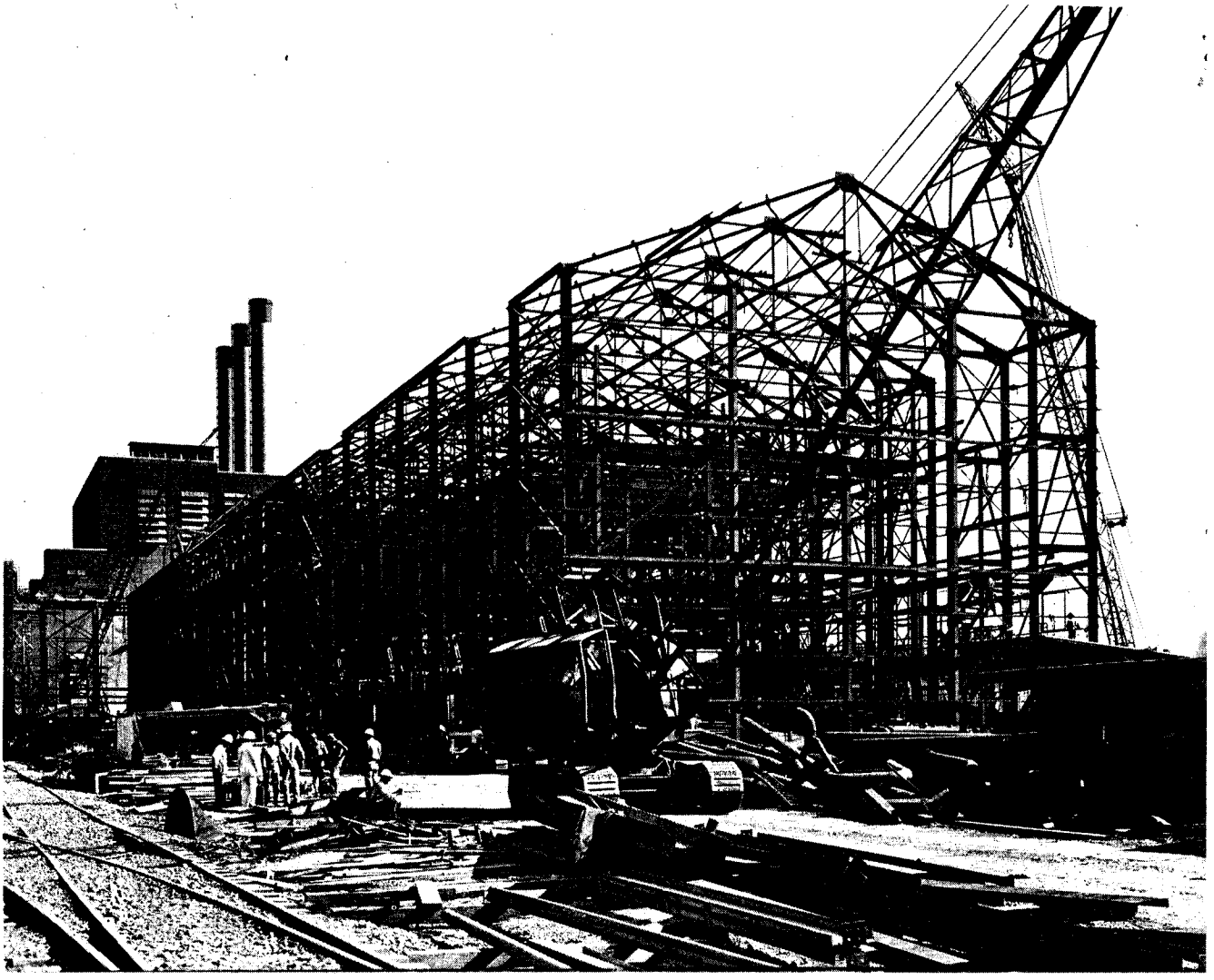


FIRST PILE AREA AT HANFORD, WASHINGTON, JUNE 1944. *Pile building is at right center.*

Oak Ridge was already the fifth largest city in Tennessee and Richland was almost as big as Walla Walla. Still, the ultimate goal was a long way off. The only major plant in operation was a painfully slow producer and the other two were question marks. Time was growing short; D-day in Europe had come and gone and the tentative date for invading Japan was October 1945. Failure to fulfill the MED mission—to perfect the weapon and use it strategically against the enemy—would, Groves knew, trigger a congressional investigation to end all congressional investigations. Far more disturbing to him was the thought of a longer war and longer casualty lists. Most men would have cracked under such pressure. Fortunately, Groves was not the worrying type, and never, even inwardly, did he lose heart. Faithful to the Corps motto, "Essayons," he kept trying. "There was only one thing to do," he said, "do our best and that we did."[109]

When he found a steep path straight ahead, he detoured along a route rejected as impracticable early in the race for the bomb. On the day of his appoint-

[109] Groves, Speech before the 11th Armored Div, 16 Aug 47. MED Files. 201 (Groves, L. R., Lt. Gen.) (Misc.).



S-50, THERMAL DIFFUSION PLANT UNDER CONSTRUCTION

ment in September 1942, he had visited the Naval Research Laboratory in Washington to learn what he could about liquid thermal diffusion, a separation process under development there. Viewing the apparatus, a tall, externally cooled tube with a steam heated cylinder inside, he was unimpressed. True, the experimental model seemed to work; but a full-scale plant was unthinkable. Its cost would be at least two billion dollars, and so insatiable would be its appetite for fuel that the output of all the country's coal mines might be insufficient to provide the necessary steam. No one at that time thought of carrying the process only part way. In June 1944 such a thought occurred to Oppenheimer. Telephoning Groves, he suggested in the double talk they always used that they had missed the boat; a small thermal diffusion plant could produce enriched feed which would double the yield of Y–12.[110] "Absolutely right," Groves promptly agreed; the big question was "how fast can we build it." After check-

[110] Groves, *Now It Can Be Told*, pp. 23 and 119–20.

ing the Navy's progress, he brought in the H. K. Ferguson Company as AEM. Then he sent for Colonel Fox, handed him the project, and deliberately provoked his rage in order to extract from him the utmost in effort. On the crucial point of completion time, Groves stated that the job could be finished in six months, to which Fox assented, whereupon Groves came back with the breathtaking dictum: "I'm not going to give you six months; you have to do it in three."[111] Bitter in his reaction, Fox denounced Groves as a "double-crosser" and complained to Nichols, "This is impossible."[112] Groves never let up. Terming the three-month deadline "reasonable," he wrote to Fox: "I think you can beat it."[113]

Renewed determination infused the whole atomic project. Insistent appeals to war manpower and war production authorities earned MED first call nationwide on labor and an AA-1 priority on materials. Dismantling operations at surplus munitions plants released hard-to-get components. Furloughs for plumbers in the armed services and extra inducements for civilian electricians eased shortages in critical trades. Enlisted strength of the Special Engineer Detachments soared to more than 3,100 men. Construction surged ahead at Clinton in the summer of 1944, as 37,000 workers pushed the two main separation plants toward completion and builders in the town of Oak Ridge assembled hundreds of new-model prefabricated houses. At the recently begun thermal diffusion plant, code-named S-50 and known locally as the "Fox farm," the pace was breakneck; for example, structural steel was taken off one day, ordered the next, and rolled the third. At Hanford the pace was literally killing; early in July the deputy area engineer, Colonel Kadlec, died of a heart attack, an apparent victim of strain and pressure. Likening the construction workers to combat soldiers, Patterson summed up the MED credo: every day saved in getting the job done would shorten the war by at least one day.[114]

Remaining obstacles toppled one by one. Phenomenal exertions by manufacturing firms culminated as shipments of vital parts reached Clinton: zirconium insulators, which signaled the end of Y-12 electrical failures, from the Coors Porcelain Company; 48-foot copper and nickel columns, the principal items of S-50 process equipment, from the Mehring & Hanson and Grinnell Companies; nickel-plated, corrosion-proof pipe, essential for K-25, from the laboratories of Blasius Bart, developer of the Corps' metal mirror searchlights; and, most happily, the first diffusion barriers, from Houdaille-Hershey's Decatur plant, built originally for one process and recently converted to another. A two-year effort by DuPont to can uranium at last bore fruit; aluminum-jacketed slugs would be ready when the time came to load the Hanford piles. Construction,

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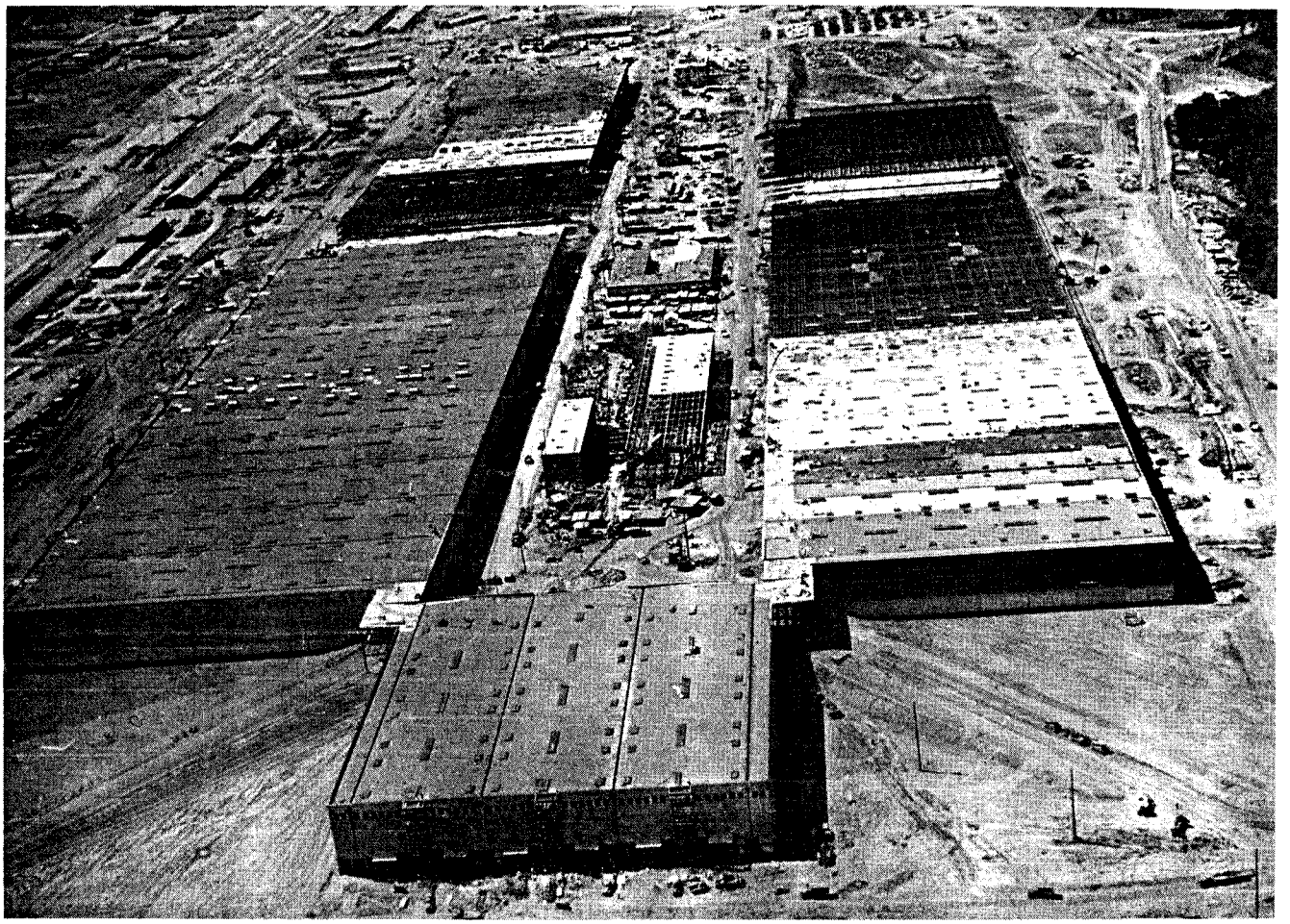
[111] Groves Interv, 11 Feb 64. See also Memo, Nichols for Groves, 11 Oct 44. MED Files, 337 LC.

[112] Interv with Col Mark C. Fox, 19 Mar 69.

[113] Ltr, Groves to Fox, 3 Jul 44. MD Hist, Book VI, Appendix D1.

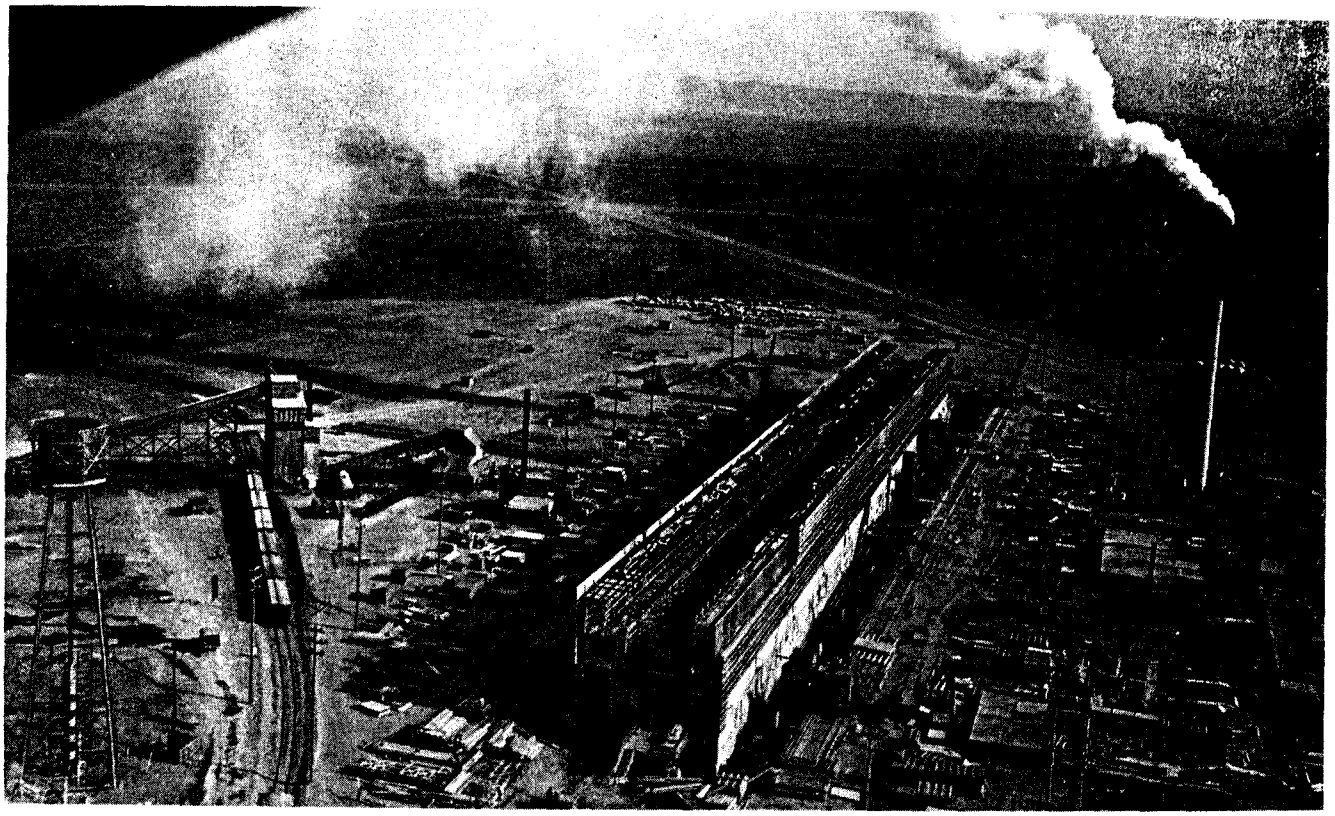
[114] (1) MED 400.1301 (Priority). (2) 400.225 (CEW). (3) Groves, *Now It Can Be Told*, pp. 99-102. (4) 600.1 (HEW) (Labor) I. (5) 220.3 (MDO). (6) Lt. Col. Mark C. Fox, "Thermal Diffusion Plant Built Rapidly," *ENR*, December 13, 1945, p. 133. (7) Matthias Diary, 2 July 44. (8) Message, Patterson to Men and Women of Hanford, 10 July 44. MED Harrison-Bundy 80-MD Proj.



K-25, GASEOUS DIFFUSION PLANT NEARING COMPLETION

meanwhile, streaked ahead, holding stride in the home stretch. Incorporating simplified and improved designs (steel-frame, asbestos-siding structures and rectangular racetracks), the Y–12 extension proceeded much faster than the original plant. With barriers finally on the way, the K–25 team gave utmost effort to completing the giant U and speeding installation. Situated alongside the K–25 powerhouse and dependent upon it for steam, S–50 made spectacular progress; with Ferguson engineer Wells N. Thompson, Colonel Fox contrived unusual shortcuts: tailoring plans to available stocks of steel, using ugly but plentiful corrugated iron siding, transporting supplies in passenger trains, and more. Still somewhat handicapped by labor unrest, Hanford scored big gains through bold engineering. Visiting the job in August 1944, General Robins witnessed one especially noteworthy feat, concreting the roof of the separation building—its walls 800 feet long and 60 feet wide with no intermediate supports—through the means of traveling forms similar to those used in tunnel lining. Step by step, constructors were winding up their work and plant operators were taking charge.

The shakedown runs were cliff-hangers. The deadline-beating startup of S–50 on 15 September 1944 was posi-



SEPARATION BUILDING AT HANFORD, SUMMER 1944

tively hair-raising. When operators turned on the steam and jetted it with saturant cold water, all hell broke loose. "That kind of stress, you know," Fox explained, "when cold water hits extremely hot and extremely high pressure steam—why it just shook those great big pipes like a dog shaking a rag. Everybody started running for the doors."[115] Soon the plant was leaking like a rusty boiler. When, in mid-October, the first token delivery went to Y–12, weeks of patching and fixing lay ahead. Wednesday, 27 September 1944, was Hanford's day of reckoning. With the first pile loaded and ready, Fermi gave the signal to begin. As control rods were withdrawn, the chain reaction started, continued for some hours, and then mysteriously died. Bystanders went weak with disappointment. Something had gone radically wrong. The error came to light fairly quickly: a mistake in the scientists' purely theoretical calculations.[116] Thanks to DuPont, the corrective was at hand; when all the spare tubes in the pile were loaded with uranium, the chain reaction went. A company balladeer summarized it neatly: "The tale's been told, as well you know,/ That Hanford nearly flopped, although/ The piles were later made to go/ Through brilliant engineering." "When the crisis came," the safety factor was the "trick that saved the game."[117] The initial test of K–25 early in the new year also proved suspenseful, as cycling and recycling of

[115] Fox Interv, 19 Mar 69.

[116] Nichols Interv, 18 Feb 64.

[117] Quoted in Compton, *Atomic Quest*, pp. 192–93.

uranium gas through the first stages of the cascade revealed defects in pumps which required last-minute modification. While trial runs were under way at other plants, Y–12 came into its own. Aided by Ruhoff, who swapped jobs with Kelley in September 1944, Tennessee Eastman engineers had whipped the bugs out of the chemical purification processes. By March 1945, all plants were in operation, production was on the rise, and bulk quantities of bomb stuff were in prospect.[118]

At Clinton and Hanford all was ending well. The final, climactic scenes of the atomic drama would take place elsewhere.

Zia

Most secret and sensitive of all MED projects, Los Alamos or Zia was also the most turbulent.[119] Conceived as an ivory-towered physical laboratory with a staff of 150 scientists and technicians, the remote mountain hideaway developed by rapid fits and starts into a quasi-military compound jammed with 7,000 people whose purpose embraced ordnance, metallurgy, and engineering as well as physics. Perched high on the Pajarito Plateau, amid a scenic wilderness, the mesa smouldered with discontent. Crises were recurrent and intense. An out-of-the-way location, improvised plans, wartime shortages, and a never-changing deadline—"as soon as possible"—made construction hard going. Austere living conditions, cloak-and-dagger security, the ever-present uniforms, and an almost eerie atmosphere, coupled with the great practical difficulties of producing the bomb, kept the scientists on edge. For the officers who commanded there, the post was a sore trial. The construction men who toiled there knew the place as "The Hectic Hill of the Sun God."

Even by MED standards the setup on the Hill was strange. A scientific laboratory operated by the University of California and an Army installation under the Chief of Engineers, Los Alamos had two heads, a civilian director, Dr. Oppenheimer, and a commanding officer, initially Colonel Harman.[120] The dividing line between them, tolerably clear in theory, was in fact somewhat blurred, for both had a hand in security and both were concerned with welfare and morale. On paper, neither at first had anything to do with construction, which was the province of the Santa Fe Area, established for the purpose at Groves' request by the Albuquerque District; but actually both entered into it. What was even more anomalous, the project lay outside normal channels of command. Deeming secrecy most vital there, Groves sealed off Los Alamos from the rest of MED. Leaving only routine administrative matters to Marshall and Nichols, he ran the show himself. "You might say," he stated, "that Los Alamos was right under my thumb all the time."[121] Few details were too small to interest him, and his often quick decisions were authoritative. Likened by

[118] (1) Hewlett and Anderson, *The New World*, pp. 299–300. (2) Kelley Interv, 14 Oct 68.

[119] Unless otherwise indicated the following section is based on MD Hist, Book VIII; and USEO, Albuquerque, N. M., Zia Project, Compl Rpt, 1 Dec 43, and Supplement, 1 Apr 44.

[120] (1) Ltr, Groves to Somervell, 27 Feb 43. MED 322 (Los Alamos). (2) Groves, *Now It Can Be Told*, pp. 53–54.

[121] Groves Interv, 11 Feb 64.

one resident to "an absentee landlord, mysterious and unseen,"[122] Groves exercised control by means of frequent visits and constant telephone calls.

For M. Eugene Sundt, as for Oppenheimer, the winter of 1942–1943 "had hardly hours enough to get Los Alamos established."[123] While the physicist combed the nation's campuses, seeking recruits for "Oppie's army" and begging or borrowing laboratory gear, the contractor's project manager sped preparations at the site. Arriving at Santa Fe on 1 December, Sundt began a whirlwind buildup, renting space at 215 Water Street, cornering local materials markets, transferring men and equipment from a nearly completed company job at Camp Luna near Las Vegas, staking out a thousand-man construction camp, and sending for his uncle, an architect, to set up a drafting room and start cranking out plans. No sooner had the area engineer, Capt. Hubert L. Shepard, opened shop in the Bishop Building on 9 December than Sundt had him tracking down generators, pumps, boilers, and other scarce items.[124] When Willard C. Kruger & Associates of Santa Fe signed on as architect-engineers in late December, bulldozers were already roaring up and down the mesa scooping out roads and foundations. Among Kruger's early recollections of the job was an encounter with Groves; early one morning, after working until two or three o'clock the night before, Kruger and Oppenheimer found the general waiting for them miffed because they were five minutes late.[125] Groves' impatience was infectious. Referring to the breakneck pace at other war projects, Shepard's assistant, Capt. James A. Loughridge, said, "But this was even faster."[126]

"A terrible job, involving many difficulties," was Groves' capsule summary of Zia project.[127] Nearly all the familiar wartime problems plagued constructors on the Hill—manpower shortages, supply bottlenecks, shipping snarl-ups, and the like; and these Sundt took in stride. But some of his troubles were highly unusual. Access to the site was limited at first. At the headmaster's insistence, Secretary Stimson agreed to let the Ranch School finish out the term. Until classes ended in late January, faculty and students were in the workmen's way. Planning was spasmodic and sometimes slipshod. Change orders to the contract came thick and fast, 70 in 11 months; and scientists with little engineering sense masterminded designs for technical buildings.[128] The worst headache by far was transport. From the railhead at Santa Fe, the haul was 35 miles by one backcountry route and 46 by another. The last eight-mile stretch was a trucker's nightmare, a hazardous climb up a narrow, unpaved, cliffside road, with hairpin turns and grades up to 14 per-

[122] Bernice Brode, "Tales of Los Alamos," *LASL Community News*, June 16, 1960, p. 6.

[123] AEC, *Oppenheimer Hearings*, p. 12.

[124] (1) Ltr, J. K. S. Walter to M. E. Sundt, 15 Mar 69. EHD Files. (2) F. E. Baumer, Los Alamos, 1943 (MS), 1969. EHD Files. (3) Interv with M. Eugene Sundt, 4 Feb 69.

[125] (1) Peggy Pond Church, *The House at Otowi Bridge* (Albuquerque: University of New Mexico Press, 1959), p. 83. (2) M. E. Sundt, Zia Project Notes (MS), 1969. EHD Files.

[126] Interv with Col James A. Loughridge, 28 Jun 68.

[127] Groves Interv, 11 Feb 64.

[128] (1) Ltr, Stimson to A. J. Connell, 1 Dec 42. EHD Files. (2) Ltr, Shepard to M. M. Sundt Constr Co., 1 Jan 43. EHD Files. (3) Contract W-911-eng-1667, 5 Dec 42, and supplements. (4) Groueff, *Manhattan Project*, pp. 197–98.

cent; "not a road but an obstacle course," Sundt pronounced it.[129] Vehicles took a merciless beating. Only "by the Grace of God and an abundance of welding rod, ingenuity, and baling wire," said one company official, was the maintenance problem "ever solved."[130] Through God's Grace and man's improvisation ("They called us 'substitute and laminate,' " Sundt remembered), other problems got solved, too. Spring found the once lovely mesa strangely transformed by drab apartment units, bleak TO barracks, makeshift laboratories, and forbidding chain-link fences. The job was generally ahead of schedule and by mid-May completion seemed assured.

Discord racked the infant community. Hustled to New Mexico ahead of time, several hundred civilians converged on Los Alamos between mid-March and early May. Their first reactions ranged from indignation to despair. Mindful that war demanded sacrifices, Groves had decreed no frills. "These scientists will like anything you build for them," he told Marshall. "Put up some barracks. They will think they are pioneers out here in the Far West."[131] Like it the scientists did not. Paper-thin walls, inadequate wiring, and old-fashioned cookstoves; no sidewalks, no telephones, no gas, no bathtubs except in the group of Ranch School houses christened "Bathtub Row," and, worse, no school. One wife wept when she saw her new home; another bolder woman reportedly challenged Groves to prepare dinner on her "Black Beauty" range; and Oppenheimer hired his own architect, Bernis E. Brazier, to design a school.[132] The technical area became a scene of conflict, as scientists occupied laboratories that were still under construction. Some mornings, craftsmen would arrive for work to find entries barred and Sundt's superintendent would swear "like a sailor" over time lost.[133] Colonel Harman soon clashed with Oppenheimer. With the arrival of 250 troops, Engineers and MP's, and the formation of a most unmilitary town council, the rift widened. On visits to Groves' office Oppenheimer learned to know Lt. Col. Whitney Ashbridge, a Philadelphia patrician, MIT graduate, and Corps Reservist, who had attended the Ranch School. In May, when Oppenheimer suggested that Ashbridge be assigned to Harman's staff, Groves went him one better. On the 31st Ashbridge began a tension-filled, 18-month tour as commanding officer on the Hill.[134]

With the new commander came orders to expand. Added missions—bomb stuff purification and ordnance-ballistics work—and corollary staff increases spurred a topsy-like growth. Housing for a population that would double, redouble, and double again before the end of the year, enlarged water and power supplies, a modern 8-room school, an air conditioned and dustproof chemical-metallurgical laboratory, and a proving ground at Anchor Ranch a few miles to the south were major features of

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[129] (1) Ltr, J. S. Sundt to SWD, 1 Feb 45. MED 161. (2) Sundt Interv, 4 Feb 69.

[130] Answers to Questionnaire, William E. Naumann to authors, 3 Mar 69.

[131] Marshall Interv, 29 Apr 68.

[132] (1) Lansing Lamont, *Day of Trinity* (New York: Atheneum, 1965), pp. 49–50. (2) Brode, "Tales of Los Alamos," June 2, 1960, p. 7; and June 30, 1960, pp. 5–7.

[133] Loughridge Interv, 28 Jun 68.

[134] (1) M. E. Sundt, Zia Project Notes. (2) Interv with Col Whitney Ashbridge, 3 Mar 64.

the fast burgeoning program. Fresh vitality infused the job. Col. Reuben E. Cole, newly appointed engineer at Albuquerque, reinforced the area office with long-time district stalwarts, including crack expediter Capt. Frank E. Wilson. Company president John S. Sundt moved with a large retinue to Santa Fe to stay with the job to the end. Lowdermilk Brothers of Denver, under contract to the New Mexico State Highway Department, started improving the tortuous road. A recruitment drive by the Engineer Department and the unions brought craftsmen to the Hill from points as far away as Omaha. A powerful Corps-wide procurement effort worked miracles; soon air shipment of materials was more or less routine, and Zia had more copper than some construction veterans had ever seen before.[135]

The Hill grew more hectic as summer wore on. Several hundred loads a day—freight from the railhead at Santa Fe, brick from the local penitentiary, and aggregate from the Rio Grande—moved in over the now partially torn up road. Truckers fought for every mile, battling dust and detours. Fifty "damn good trucks" wore out and even the MED priority could produce only second-hand replacements. A far more accessible project started in July, at Bruns General Hospital in Santa Fe, siphoned off men from Los Alamos. Indians and farmers of Mexican descent became mainstays of Sundt's 3,000-man labor force. But neither worked full time. Hopis, Navajos, Jemez, and San Ildefonsos each went off in a body for their tribal dances. "No sooner would one group return from the Corn Dance," John Sundt complained, "than it would be time for the Antelope Dance of another group, . . . [or] the Harvest Dance, or Rain Dance, or Snake Dance." Similarly, the farmers took leave to tend their crops.[136] Meanwhile, Brazier's activities gave rise to awkward complications. His design for the school proved costly, and when Groves discovered this "glorious extravagance," the area engineer bore the brunt of his displeasure and got orders to depart. With Oppenheimer's backing, Brazier cut a wider swath. Forming a separate construction division, he assembled a staff of about 250 men. He and his associates issued orders on a day-to-day basis, often disrupting the conduct of the job.[137]

For everyone at Los Alamos, water was a supercritical problem. According to Indian belief, the spirits in the nearby sacred burial grounds had called upon the gods to doom White settlements in the area. In the early years of the Ranch School, the gods played havoc with the water supply. With the coming of the Army in late 1942, they waxed wrathful anew. Little snow fell that winter and no spring runoff filled the reservoir in Los Alamos Canyon. Soon water was low. A hydrologist from the Albuquerque District recommended a pipeline to the creek in Guaje Canyon, some six miles to the north; but Groves, on advice from Ray

[135] (1) Ltr, Ashbridge to Cole, 26 May 43. (2) Ltr, Groves to Cole, 17 Jun 43. Both in Zia Compl Rpt, 1 Dec 43. (3) Ltr, J. S. Sundt to SWD, 1 Feb 45. MED 161. (4) Roundtable Discussion, J. A. Remington with J. R. Brennand, J. A. Loughridge, R. O. Ruble, E. N. Sanchez, and F. E. Wilson, 4 Feb 69.

[136] Ltr, J. S. Sundt to SWD, 1 Feb 45. MED Files 161.

[137] (1) Brode, "Tales of Los Alamos," July 14, 1960, p. 7. (2) Ltr, Ashbridge to Shepard, 10 Jul 43, and related docs in Zia Compl Rpt, 1 Dec 43. (3) M. E. Sundt, Zia Project Notes.

Lawrence of OCE, decided to try a quicker and easier solution—lines to several nearby smaller streams. Perhaps failure was preordained. The summer was the driest in many years and, with the sharp rise in population, Los Alamos became a town that said Grace when the faucets flowed. Algae fouled the reservoir, and Ashbridge had to restrict the use of water. As anxiety mounted within the community, Groves gave orders for a surface line to Guaje to be laid within a month.[138] The country was rugged, some of the roughest and wildest in the United States; and much of the government-furnished pipe was second-hand, "strings of holes held together with rust," old pipeliners described it; but by prodigious efforts Sundt finished up on time. When the valves were opened early in October, portions of the line "looked like the fountains at Versailles."[139] Patched, repatched, and winterized, the Guaje conduit saw the project through to the end of the war—but barely, for water was always short and the supply always precarious.

The contractor had demobilized his forces and the Santa Fe Area was preparing to shut down, when in late 1943 another great expansion engulfed the project. Discovery that gun-type assembly, the most straightforward detonation method, might not work with plutonium prompted a frantic drive to develop an untried technique—implosion. Whereas the gun device would fire one subcritical mass of bomb stuff into another to create an instantly exploding supercritical mass, implosion would involve a sphere-shaped charge designed to burst inward and compress fissionable material to produce a nuclear blast. The new scientific thrust would mean more people and more facilities. With another crash construction program at hand, the question arose how best to organize. Maj. Frank M. Newell, whom Colonel Cole had brought from the Tulsa District to head the area office, wished to import an Oklahoma firm to replace the capable, but outspoken Sundts. Cole, who felt the Tucson outfit had done a splendid job, agreed that new blood might be beneficial; after months of 14- to 16-hour days and 7-day weeks, Sundt's men seemed near exhaustion. Vetoing Newell's suggestion, Cole chose two El Paso companies, J. E. Morgan & Sons to erect 28 prefabricated duplex apartment buildings and Robert E. McKee, one of the largest general contractors in the Southwest, to construct a small explosives plant and a plant for shaping charges at "S" site, one mile south of Anchor Ranch.[140] Kruger stayed on as architect-engineer. Meanwhile, Ashbridge assumed a larger role. Absorbing Brazier's staff, he established a Post Operations Division, to be headed, first, by Maj. Frank W. Salfingers and, later, by Lt. Col. Wilber A. Stevens. Upon completion of current contracts with Morgan and McKee, the area would drop out of the picture and all future construction would come under Ashbridge.

Morgan and McKee performed well under adverse circumstances. The win-

[138] (1) USEO, Albuquerque, N. M., Rpt on Water Supply, Los Alamos Project, 9 Oct 43. 670.1 (Los Alamos, N. M.). (2) Ltr, Groves to Cole, 25 Aug 43. Zia Compl Rpt, 1 Dec 43.

[139] Answers to Questionnaire, William E. Naumann.

[140] (1) Interv with Maj Frank M. Newell, 17 Jan 69. (2) Interv with Col Reuben E. Cole, 28 Jun 68.

ter of 1943–1944 was extremely hard. Temperatures dropped as low as minus 28 degrees, and only the very old men in the San Ildefonso Pueblo could remember "so much snow on the ground for so many weeks."[141] When the contractors started work in mid-January, a 3-foot cover blanketed the site, and during the next 8 weeks snowfall totaled 24 inches. Scrapers toiled overtime heaping snow into piles that did not melt completely until July. "Snowed all the time," Morgan superintendent Herbert N. Sherwood recalled. "Everything was frozen," McKee manager Jack R. Brennand said—earth, water, and, at times, freshly poured concrete.[142] Even so, there were no major delays. Sherwood finished "Morganville" on 15 March, right on schedule, and Brennand beat his 1 April deadline by 15 days. When Ashbridge invited both firms to bid on a new administration building, McKee submitted the lower offer. Thus began a lasting affiliation. Although force account crews handled small, routine jobs, McKee did most of the construction work from this point onward, enlarging the technical area, providing hutments, quonset huts, and trailer camps for the mushrooming population, and building at 25 outlying sites, including the fabled "DP" bomb-assembly area. In the postwar period, Zia Company, a McKee subsidiary, would furnish management and maintenance services and carry out construction for the Los Alamos Scientific Laboratory.[143]

When Oppenheimer first explained his plan for a mesa-top Shangri-La, Met Lab scientist Leo Szilard predicted that everyone who went there would "go crazy."[144] At times in 1944 this prophecy appeared to have been fulfilled. Latecomers to the Hill found a world of barbed wire fences, armed guards, and snarling patrol dogs, where mail was censored and telephones were tapped, a world of spreading slums and pinching privations, where the austere Sundt Apartments were called "Snob Hollow," where fresh milk, vegetables, and meat were occasionally in short supply, and where water and power were rationed. Uniforms were much in evidence. Every third laboratory worker belonged to the Special Engineer Detachment; many of these men, naturally disgruntled, were former Los Alamos civilians, drafted and put back in their old jobs as GI's. Other soldiers were mocked as security "creeps" or custodial "plumbers" by the citizenry at large. Hostilities ran deep and factions flourished. Grievances were many and forcibly expressed. Ashbridge's background placed him at a disadvantage. The Gentleman's Code did not envisage name-callers, mischief-makers, and housewives who flung hamburger on the commander's desk, shrieking "dogmeat." The continual turmoil took a physical toll. Ashbridge developed a heart condition, and at the Amarillo airport, on a trip back from Washington, he collapsed. Played out by the long ordeal at Los Alamos, he left soon for a calmer post in the South Pacific.[145] Fortunately, a replacement

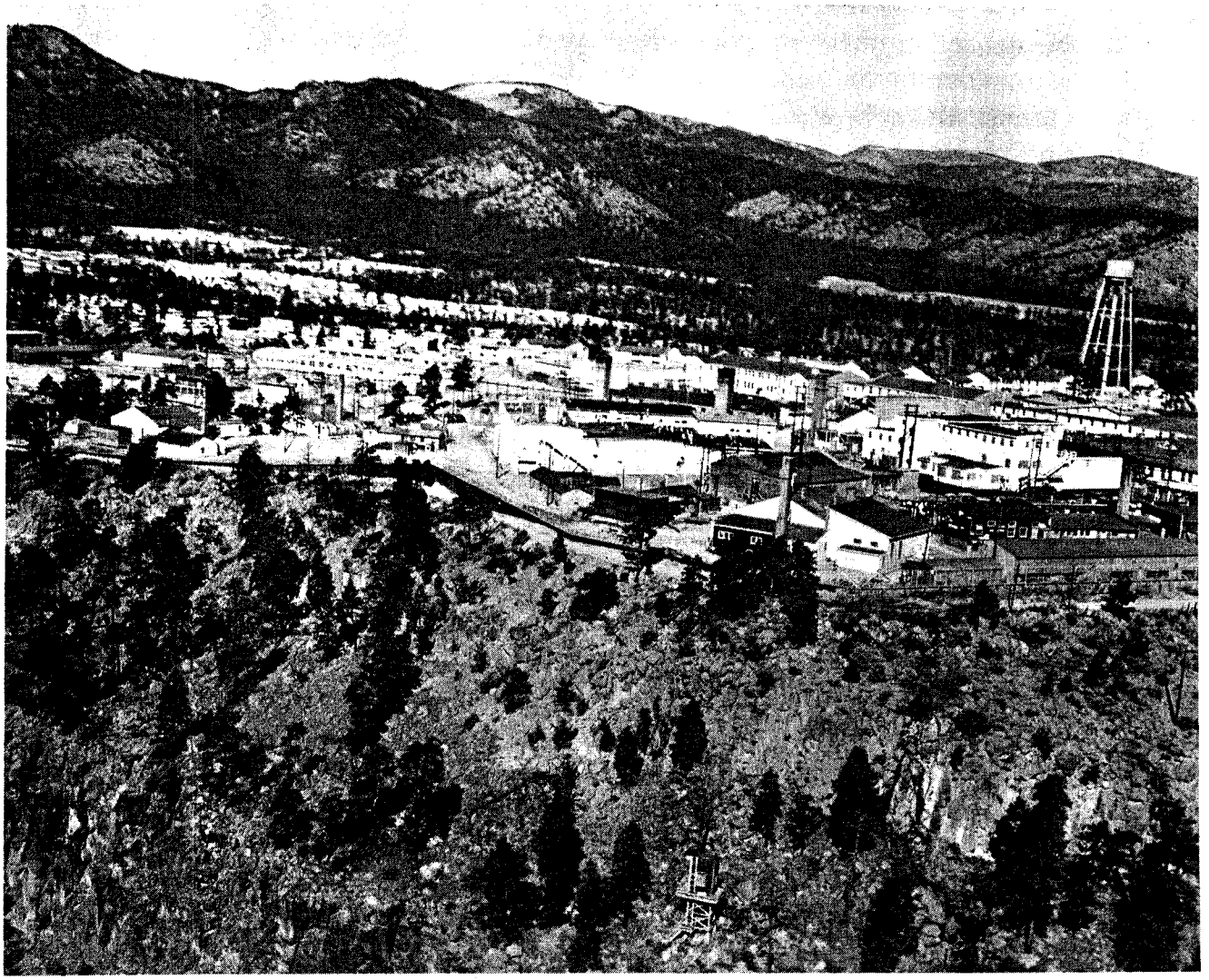
[141] Church, *Otowi Bridge*, p. 126.

[142] (1) Interv with Herbert N. Sherwood, 15 Oct 69. (2) Interv with Jack R. Brennand, 4 Feb 69.

[143] Robert E. McKee, *The Zia Company at Los Alamos: A History* (El Paso: Carl Hertzog, 1950), pp. 1–2.

[144] Nuel P. Davis, *Lawrence and Oppenheimer* (New York: Simon & Schuster, 1968), p. 163.

[145] (1) Ashbridge Interv, 3 Mar 64. (2) Lamont, *Day of Trinity*, p. 63.



VIEW OF LOS ALAMOS

was at hand. Col. Gerald R. Tyler, always steady and reliable, had just come off the Alcan Highway. Groves' instructions to Tyler were revealing:

> The scientists detest the uniform. They'll make your life a hell on earth and will do everything they can to embarrass you. When you start talking to them about property accountability, . . . they'll scream that you are a Fascist and that you are trying to regiment them. Your job will be to run the post. Try to satisfy these temperamental people. Don't allow living conditions, family problems, or anything else to take their minds off their work.[146]

Tyler's regime was relatively peaceful. Perhaps it was his firmness, tempered by forthright exercise of justice and a saving sense of humor, that calmed the ferment. Presented with a list of demands by the town council, the newly appointed commanding officer announced that he would entertain requests, not demands. He added that the first person, man, woman, or child, who threw hamburger onto his desk would "go straight through my screen window."[147] Knowing Groves well and enjoying his confidence, Tyler was

[146] Tyler, Résumé of Instructions, Oct 44.

[147] Lamont, *Day of Trinity*, p. 64.

able to persuade him to spend more money for improvements and ease up a little on constraints.[148] Perhaps, too, good fortune played a part. When Tyler took over in late 1944, the scientific outlook was improving; riddles of bomb design were yielding one by one and emphasis was shifting from research to development and production. With the new year, the tempo changed from presto to prestissimo. Efforts to perfect the gadget became almost ceaseless; and men from the laboratory joined in wide-ranging preparations, helping to ready the special air group that would drop the bomb, to choose targets, and to plan the take-off from Tinian, in the Marianas, 1,500 miles from Tokyo. After Germany capitulated on 7 May, the pace grew "still more frantic," for MED leaders wished to get the job finished "before the war was over and nothing much could be done."[149] Resentments were largely forgotten as excitement mounted to fever pitch and everyone gave his all to crown the project with success.

Increasingly, attention focused on the Jornada del Muerto, the Journey of Death, a desolate desert area in southern New Mexico dreaded by long-ago conquistadors, now a part of the Alamogordo Bombing Range. Recommended to Groves by a committee of scientists and engineers as an acceptable nuclear test site, the Jornada took the code name "Trinity," a word not to be spoken aloud. The uranium gun, a surefire weapon, could be battle tested, but the uncertain implosion device cried out for a prior test; a dud, if combat dropped, would give the show away and might put precious plutonium in enemy hands. In the late fall of 1944, Colonel Tyler sent 100 Engineer troops under Capt. Samuel P. Davalos to establish a base camp for the one-shot experiment. Using CCC building sections furnished by the Albuquerque District, the J. D. Leftwich Construction Company of Lubbock, Texas, quickly provided berths for Davalos' detachment, 100 MP's, and several hundred scientists. Meantime, at the Albuquerque office, a picked group of civilians, isolated in a separate room, rushed plans and layouts for the desert proving ground. A local outfit, Brown Brothers Construction Company, called in by Colonel Cole in mid-December, discovered that nothing to be built was unusual but that pressure for speed was extreme. "Hotter than anything we had ever gotten hold of," firm president Theodore R. Brown described the project.[150] Along with husky Engineer GI's and tenderfoot professors, Brown's 100-man force endured oppressive heat, talcum-fine volcanic ash, Gila monsters, scorpions, and other noxious creatures, and monastic seclusion. Despite hardships, work steadily advanced on roads, bunkers, magazines, a communications hookup, a power system, and a network of control points; on an unloading platform at Pope, New Mexico, for Jumbo, the giant steel vessel designed to contain the atomic explosion but never used; on a 20-foot wooden tower for the 100-ton trial blast of TNT set off on 7 May; and, finally, on a job entrusted to the Eichleay Corporation of Pittsburgh, Pennsylvania —erection of the 100-foot steel tower that

[148] Interv with Col Gerald R. Tyler, 24 Feb 64.
[149] AEC, *Oppenheimer Hearings*, pp. 31–32.
[150] Interv with Theodore R. Brown, 28 Oct 69.

would cradle the bomb. By 15 July all was in readiness.[151]

The predawn detonation on the 16th ushered in the Nuclear Age. The power of the bomb exceeded all expectations. The details were almost beyond belief: the huge fireball, mushrooming to a height of 10,000 feet; the massive cloud of radioactive dust, billowing up into the stratosphere; the brilliant light visible at Santa Fe, 180 miles away; and the "awesome roar which warned of doomsday." Witnesses reacted each in his own way. Oppenheimer, a sensitive man and a student of Eastern religions, recalled a snatch of the *Bhagavad-Gita:* "I am become Death, the destroyer of worlds." Fermi, coolly scientific, noted the "very intense flash of light," the "sensation of heat" on exposed parts of his body—and then, by a simple experiment with bits of paper, correctly measured the force of the blast as 20,000 tons of TNT.[152] Groves' feeling was largely one of profound relief. "I personally thought of Blondin crossing Niagara Falls on his tightrope," he recorded, "only to me this tightrope had lasted for almost three years, and of my repeated, confident-appearing assurances that such a thing was possible and that we would do it."[153] Seen through any eyes, the shot was a stunning success. For the good or ill of mankind, atomic energy was here to stay.

Reflecting on the Allied victory in World War II, General Reybold counted American construction power as a decisive factor. Production of atomic bombs had been "primarily a problem of engineering design and construction of plants." Similarly, camps and cantonments had been key to mobilization; munitions plants, to rearmament; and airfields, to air superiority. The American achievement had amazed the world. The secret of this remarkable performance lay in the rapid conversion of the rivers and harbors organization from peace to war, the consolidation of all military construction under one agency, and the skilled efficiency of the Army-industry building team. Knowledge of this secret offered hope for the future; Reybold saw reliable construction power as "the cornerstone of an enduring America."[154] History seemed likely to confirm his view.

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[151] (1) Ltrs, Groves to Cole, 8 Nov and 1 Dec 44. MED 600.1 (Santa Fe) thru 1944. (2) Tyler Interv, 24 Feb 64. (3) LASL, *Los Alamos: Beginning of an Era, 1943–1945* (LASL Brochure: n.d.), pp. 29–42. (4) Lamont, *Day of Trinity*, pp. 94–95 and 120–23.

[152] LASL, *Los Alamos: Beginning of an Era*, pp. 53–54.

[153] Memo, Groves for Stimson, 18 Jul 45. In Groves, *Now It Can Be Told*, app. VIII, pp. 438–39.

[154] Lt Gen Eugene Reybold, *Engineers in World War II: A Tribute*, pp. 1, 2, 10.